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November 30, 2006

VIA ELECTRONIC FILING

Ms. Marlene H. Dortch
Secretary
Federal Communications Commission
Washington, DC 20554

      Re: *Ex Parte* Notice in WC Docket No. 02-60

Dear Ms. Dortch:

    On November 29, 2006, Doug Van Houweling, President and CEO of University Corporation for Advanced Internet Development, Inc. ("Internet2"), and I met with Commissioner Deborah Taylor Tate and her legal advisor, Ian Dillner, to discuss issues both related and unrelated to the above-referenced proceeding.

    During the meeting, we discussed the Internet2 organization in general, the applicability of Internet2's middleware efforts to protecting children online, electronic health records, and Internet2's qualifications to serve as the backbone in the pilot program established by the Commission's order released on September 29, 2006 in the above-referenced proceeding. We also discussed the issues that would arise from attempting to include multiple backbones in the pilot program pursuant to the Petition for Reconsideration filed by National Lambdarail on October 30, 2006. The substance of Internet2's position on these matters is set forth in Internet2's written comments, which are on record with the Commission. Written materials from the meeting are attached.

    Pursuant to section 1.1206 of the Commission's Rules, 47 C.F.R. § 1.1206, this letter is being filed electronically with the Office of the Secretary.

                  Respectfully submitted,

                  /s/ Gary Bachula
                  Gary Bachula
                  Vice President for External Relations

EXHIBITS PRESENTED AT THE EX PARTE MEETING OF NOV. 29, 2006

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www.internet2.edu

Internet2 science and engineering applications are at the forefront of research that spans many disciplines. Internet2 advanced networks have made it possible for scientists and researchers to share data from geographically distant locations in real-time at rates previously unachievable. These advanced network capabilities are facilitating global collaboration in fields as diverse as meteorology, high-energy physics, and earthquake engineering.

Large Hadron Collider

CERN

http://www.cern.ch

The Large Hadron Collider (LHC) is a new particle accelerator that will be used by physicists to investigate the properties of matter. The instrument is currently under development at CERN, an Internet2 affiliate member located near Geneva, Switzerland. When operations begin in 2007, it will produce roughly 15 Petabytes (15 million Gigabytes) of data annually for scientists around the world to access and analyze. Internet2's advanced networks and Hybrid Optical and Packet Infrastructure (HOPI) are essential parts of the data storage and analysis infrastructure in the United States. The data from the LHC experiments will be distributed through a four-tiered model. After a primary backup and initial processing at CERN (Tier-0), data will be distributed to a series of Tier-1 centers with storage capacity for a large fraction of the data. These centers will make data available to Tier-2 centers—a number of which are Internet2 member universities—via advanced networks around the world. The computing facilities at these sites are able to store sufficient data and provide adequate computing power for specific analysis tasks. Individual scientists will access these facilities through Tier-3 computing resources, which can consist of university departments or individual PCs.
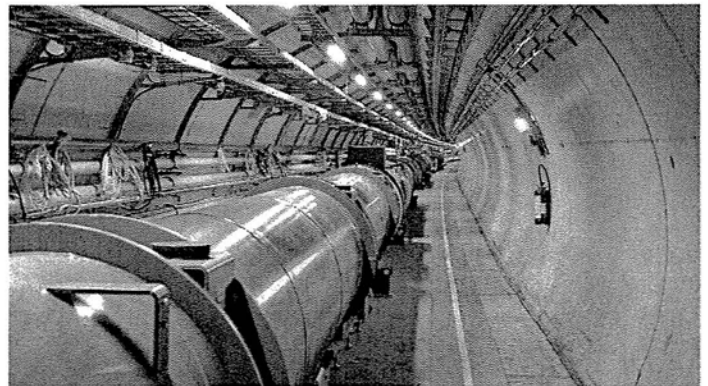

Image courtesy of CERN

Image courtesy of Vieux & Associates, Inc.

Integrated Robust Assured Data Services: High-Resolution Real-Time Weather Radar Data

UNIVERSITY OF OKLAHOMA

https://www.radarservices.org

The distribution of NEXRAD weather radar data via the Internet was pioneered at the University of Oklahoma in a project known as the Collaborative Radar Acquisition Field Test (CRAFT). CRAFT was the highly-successful prototype for the real-time transmission of meteorology data from multiple radars that led the National Weather Service (NWS) to adopt an Internet-based data transmission methodology. Integrated Robust Assured Data Services (IRADS) is an extension of Project CRAFT that is now distributing high-resolution NEXRAD Level II data from the network of over 140 Doppler radars operated nationwide by the National Weather Service. Data from each radar are transmitted to four NWS Regional Headquarters (RHQ) sites. Each RHQ server is linked to Internet2 advanced networks. From there, the data are transmitted directly to one of several top-tier sites, including the University of Oklahoma. Level II data provide the highest spatial and temporal resolution information available from ground-based atmospheric observations and are used for real time warning of weather hazards such as hurricanes and tornadoes; for initializing numerical weather prediction models; for verifying past events, such as the location of damaging hail; and for non-meteorological purposes, including bird migration studies, bird strike avoidance, and urban pollution transport.

Network for Earthquake Engineering Simulation

http://www.nees.org

Several Internet2 member universities are participants in the George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES). NEES, funded by the National Science Foundation to improve our understanding of earthquakes and their effects, includes 15 large-scale, experimental sites, which feature such advanced tools as shake tables, centrifuges, a tsunami wave basin, and field-testing equipment. Distributed across 10 states, these facilities are linked to a centralized data pool and earthquake simulation software. Data is shared between sites via the capabilities of Internet2's advanced networks, enabling the formation of a national virtual earthquake engineering laboratory. Together, these resources provide the means for collaboration and discovery in the form of more advanced research based on experimentation and computational simulations of the ways buildings, bridges, utility systems, coastal regions, and geomaterials perform during seismic events.
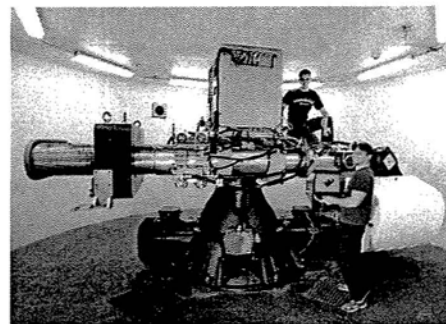
Image courtesy of Rensselaer Polytechnic Institute (RPI)

eVLBI

http://web.haystack.mit.edu/e-vlbi

Very Long Baseline Interferometry (VLBI) is one of the most powerful techniques for high-resolution imaging of distant radio sources in the universe and for making accurate measurements of the motion of the earth in space. Multiple radio telescopes scattered over the surface of the earth are used simultaneously in a powerful array to record continuous data at Gbps per telescope from a radio source, such as a distant quasar. VLBI has traditionally been done by physically shipping tapes or disk packs from the telescopes to a central correlator for processing. Internet2 and other advanced networks are now making electronic transmission of VLBI data, or "eVLBI," a reality on a global scale. The network-based eVLBI approach allows scientists to have immediate access to correlation results, even while experiments are in progress, which allows them to analyze the data immediately to make adjustments or changes in strategy to maximize the science output, or identify and fix problems at the telescopes. The eVLBI application is now able to link radio telescope facilities residing in Japan, Sweden, United Kingdom, the Netherlands, and the United States using advanced networks to stream simultaneous real-time observation data to a large correlator at the MIT Haystack Observatory outside Boston— essentially creating a virtual radio telescope with a diameter nearly the size of the Earth.

Image courtesy of MIT Haystack Observatory

The National Ecological Observatory Network (NEON)

http://www.neoninc.org

Internet2 members are increasingly aware of the challenges and opportunities associated with a new generation of sensor networks that will change the way researchers investigate earth-quakes, track ecological processes across continents, and explore the oceans by enabling them to discover previously unobservable phenomena through connection of the physical world to the Internet. One such project is NEON, a long-term continental-scale ecological observatory network designed to advance our understanding of how ecosystems and organisms respond to variations in climate and land use. The NSF-funded network will deploy standardized sensors and cyberinfrastructure across the United States to provide near real-time ecological data from 60 research sites to researchers, teachers and students. The San Diego Supercomputer Center and the Center for Embedded Networked Sensing, an NSF Science & Technology Center whose partners include Internet2 members USC, CalTech, UCLA, and several other UC campuses, are helping to design the network, using standardized sensors, field-deployed wireless communications, advanced cyberinfrastructure and Internet2 network connections, and a common set of data-collection protocols. In addition, formal and informal NEON education initiatives will help train the next generation of ecological scientists and offer web portals and modeling and visualization tools for citizens and students at all grade levels.
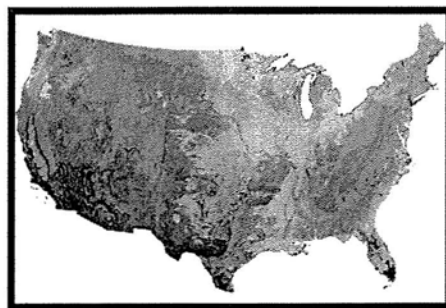
Image courtesy of the Environmental Sciences
Division of Oak Ridge National Laboratory

INTERNET

For high-speed computing to become a reality, performance needs to be addressed. Users of state-of-the-art, 10 gigE backbone networks currently encounter many of the same problems faced by dial-up users. Internet2's E2Epi is creating a framework (E2E piPEs) for identifying the source of problems; developing measurement and troubleshooting tools; collaborating with researchers on related projects to avoid duplication of effort; and fostering communication between researchers, network operators, and end-users.

E2E piPEs Architecture
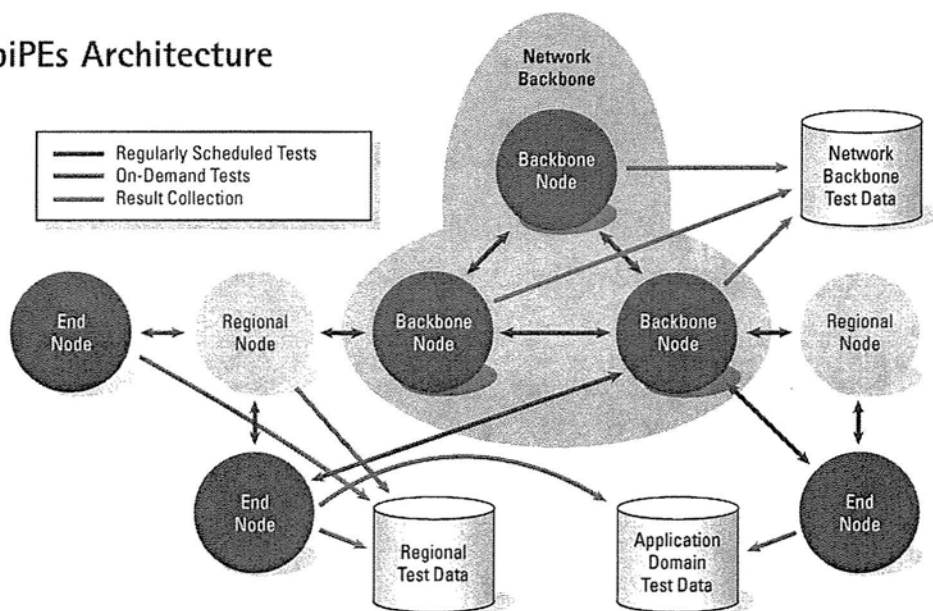
"In the ideal world, network users would have a tool that could tell a user where a problem is, what type of problem it is, and the person to contact for the resolution of the problem."

JAMES D. BRUCE
"Beyond Bandwidth," EDUCAUSE
Review, vol. 38, no. 1
(January/February 2003): 30

E2E piPEs

e2epi.internet2.edu/ E2EpiPEs/

With Internet2's E2E piPEs, the average user will have such a tool. In its final form, the E2E piPEs can determine the performance characteristics of the complete path by aggregating information about the segments that make up the path; problematic segments can be identified and reported, with supporting data, to the appropriate network administrator. The aim of this system is to reduce the "signal-to-noise ratio."

E2E piPEs is a framework that employs various tools, such as traceroute and Iperf, to run tests to provide information on loss, jitter, flow data, one-way latency, and throughput. Data collected from regularly scheduled tests is used by the Abilene Observatory to provide weekly reports on the status of the Abilene network.
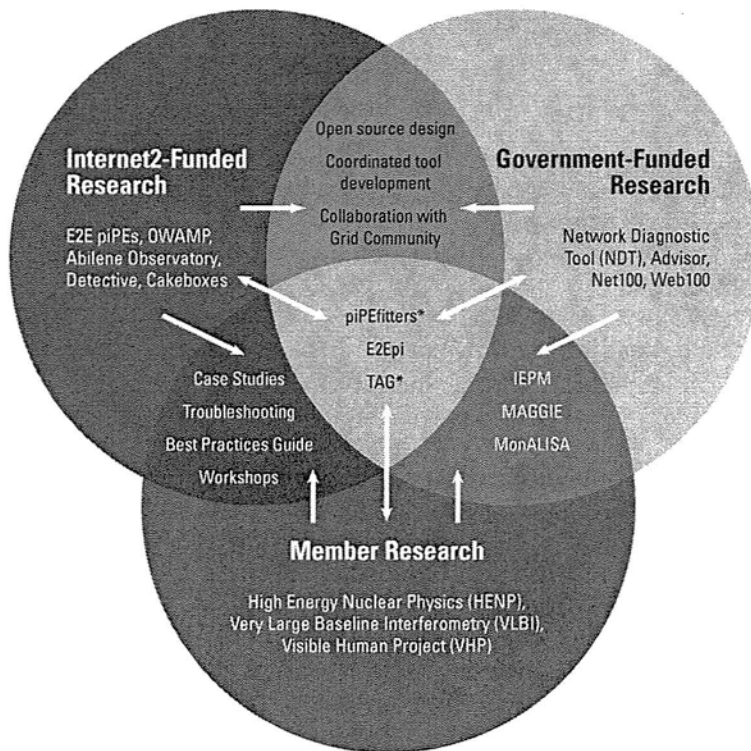
Tool Development

owamp.internet2.edu
bwctl.internet2.edu
www.itecohio.org/beacon/

The E2Epi has supported development of three tools: OWAMP (One-Way Active Measurement Protocol), BWCTL (Bandwidth Control), and the H.323 Beacon, that provide users with methods to determine the location of common end-to-end performance problems. OWAMP helps a user determine whether latency is experienced on the inbound or outbound path. The BWCTL allows the scheduling of regular and on-demand authorized throughput tests in the presence of scarce resources. These tools are used by E2E piPEs and are part of Abilene quality control.

The H.323 Beacon tool measures and monitors videoconference sessions, qualifies sessions, and can be used as a debugging tool to troubleshoot problems. This tool is used by the Internet2 Commons videoconferencing service (commons.internet2.edu).

E2Epi Collaboration

Internet2-Funded Research

E2E piPEs, OWAMP, Abilene Observatory, Detective, Cakeboxes

Open source design

Coordinated tool development

Collaboration with Grid Community

Government-Funded Research

Network Diagnostic Tool (NDT), Advisor, Net100, Web100

piPEfitters*
E2Epi
TAG*

Case Studies
Troubleshooting
Best Practices Guide
Workshops

IEPM
MAGGIE
MonALISA

Member Research

High Energy Nuclear Physics (HENP),
Very Large Baseline Interferometry (VLBI),
Visible Human Project (VHP)

*

piPEfitters: Volunteers working on specific pieces of the E2E piPEs architecture.
TAG (Technical Advisory Group): Experts who provide biweekly input on E2Epi projects.

Collaboration

Such projects as E2E piPEs and NLANR's Advisor are combining results of different measurement tools into a richer, broader, and leveraged collection of solutions for the growing knowledge base. The E2Epi has established working relationships with specific application communities (i.e., videoconferencing and multicast) and disciplines (such as high-energy and nuclear physics, radio astronomy, and health care) to help solve performance problems encountered by users. The Initiative continues to work on other Internet2-focused advanced applications, including distributed computation, digital libraries, distributed learning, digital video, tele-immersion and virtual laboratories. The E2Epi also works with such Internet2 corporate members as Apparent Networks to develop products for the Internet2 community that are appropriately tuned and provide high-performance capabilities.

Communication

Performance problems can be identified and solved more efficiently through communication—integrated and shared within an established knowledge base, using successful measurement performance stories derived from research and engineering communities. The E2Epi collects and disseminates brief case studies of problems encountered and their solutions.

The E2Epi uses their website to: disseminate these case studies; solicit member input in developing/collecting "best practices" for campus networking infrastructure and troubleshooting techniques; provide links to related documents and websites; and foster an open discussion of end-to-end performance tools, techniques, and issues (e2epi.internet2.edu).

The E2Epi has hosted several workshops on end-to-end issues, bringing together researchers, network engineers, and end-users to discuss the problems encountered and methods by which a user could be more informed. In December 2003, for example, with funding from an NSF grant, the E2Epi brought together a number of topical experts to create a "road map" of the research currently in progress and how each piece links with the others. This ensures that all the necessary measurement and performance tools are being developed and that the tools will be interoperable.

At several meetings each year, the E2Epi sponsors tutorial sessions (focusing on using the latest measurement/troubleshooting tools) and update sessions (where researchers provide status reports on related projects). The E2Epi also provides ongoing support for the Peer-to-Peer Working Group (p2p.internet2.edu) and the Measurement Special Interest Group (measurement.internet2.edu).

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www.internet2.edu

International partnerships link Internet2 members to research and education networking organizations around the world. The principal goal of Internet2 international partnerships is to enable global collaboration in research and education by providing access to advanced international networks. By creating a global proving ground for new technologies, and by providing channels for international Internet technology transfer, Internet2 international partnerships also help to ensure that the next generation of Internet technologies and applications will be globally interoperable.

INTERNATIONAL MoU PARTNERS

Internet2 international partnerships are established by signing a Memorandum of Understanding (MoU) with counterpart research and education networking organizations. Today there are more than forty-five international MoU partners, with more on the way.

Current MoU Partners
Developing Partnerships
Related Efforts in Formation

Global Proving Ground

Most international MoU partners operate networks which interconnect with Internet2's Abilene network. Internet2 works closely with its international partners, and with key Internet2 member institutions involved in international connectivity projects, to make a coherent global research and education networking infrastructure available to its members. Internet2 member institutions contribute by managing key international exchange facilities such as StarLight, Pacific Wave, MAN LAN and AMPATH, as well as international connections such as APAN/ TransPAC, Euro-Link and GLORIAD. The US National Science Foundation provides important funding to a number of these projects.
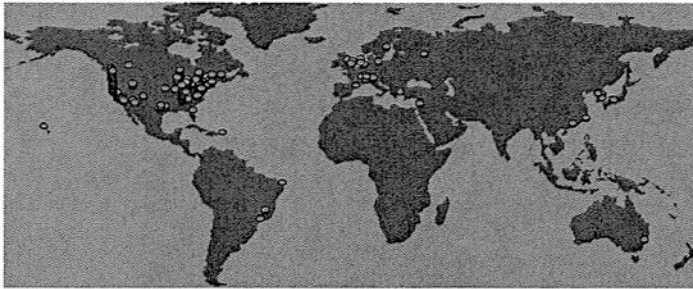
Internet2 members and international partners are using this global infrastructure to develop and test new technologies on a scale not possible in the commercial Internet. For example, partners in the United Kingdom have funded staff to work on the Internet2 End-to-End Performance Initiative's performance monitoring system, called piPEs. These partners' involvement not only provides resources to the Internet2 community, but also helps to ensure interoperability of performance monitoring systems between the US and Europe.

international.internet2.edu

Global Collaboration

Internet2 international partnerships support a wide variety of projects; here are a few examples.

European Union and US Mid–Atlantic eXchange (EUMAX)
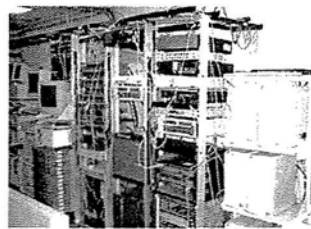*www.eumax.isn-oldenburg.de*

The EUMAX project is developing an international foreign language, business, and technology curriculum, which students will complete through a combination of online curriculum delivery and travel abroad for further study and internships. A central feature of this project is the use of high-performance videoconferencing to connect US and European universities via the Abilene and GÉANT research and education networks. EUMAX researchers are mindful that community-building and the transmission of lessons learned are crucial for the success of future endeavors of this type; providing a model for such future efforts is a principal goal of their work.

Logistical Computing and Internetworking (LoCI)
loci.cs.utk.edu

Logistical Computing and Internetworking (LoCI) is a field of research exploring the optimal coordination and use of the enormous quantities of storage, computational power, and bandwidth now available worldwide. The LoCI Lab at the University of Tennessee is leading the construction of a global logistical networking infrastructure, which currently includes data management nodes that span research and education networks on five continents. The LoCI Lab aims to integrate these capabilities to form a coherent system for the distribution, staging, processing and delivery of large quantities of data.

Virtual Network Engineering Lab (VNELab)
vnelab.cs.tamu.edu

Located at Texas A&M University, VNELab provides students of network engineering with access to state-of-the-art equipment. Texas A&M is using VNELab's Web Access Exercise System (WAES), together with connectivity between Abilene and CUDI (Mexico's national research and education network), to expand access to this equipment to students at the Universidad Autónoma del Estado de Hidalgo and the Universidad Nacional Autónoma de México.

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When you want to share secured online services or access restricted digital content, the Shibboleth system offers a powerful, scalable, and easy-to-use solution. It leverages campus identity and access management infrastructures to authenticate individuals and then sends information about them to the resource site, enabling the resource provider to make an informed authorization decision. Shibboleth software is at work today providing this capability—it's a powerful, secure, standards-based and user-friendly, interrealm access-control solution for research and education.

The Shibboleth system provides a standards-based link between existing campus authentication systems and resource providers of all kinds. For example, when a student requests access to a protected video clip, her home organization (origin site) requests her to authenticate (if she has not done so already) and then passes on the information that she is enrolled in Biology 562 to the site housing the video. The provider (target site) uses the fact that she is enrolled in this course to determine her eligibility to access the video.

Middleware components enable "transparent use," providing consistent infrastructure for security, privacy and access to protected resources:

- Identity—unique markers of person, machine, service, or group
- Authentication—how you prove or establish your identity
- Authorization—what an identity is permitted to do
- Directories—where an identity's basic characteristics (attributes) are kept

From anywhere in the world, users authenticate at their home campuses and those institutions pass information (attributes) on each user's behalf to the resource provider. Users don't need to remember multiple passwords for each restricted site to which they have access.

Below are typical scenarios that the Shibboleth system addresses:

- Enabling anonymous access (and thereby protecting personal privacy) by a member of the campus community to a licensed information resource available to "active members of the community."

- Ensuring anonymous access to a remote information resource where access is limited to "people associated with Course X at the origin site."

- Providing access to a restricted service using an attribute such as a person's name to determine authorization. For example, a team of researchers forming a multi-institutional workgroup can control the release of their attribute information to the workgroup site. In this scenario, access would be denied if an individual chose not to provide the required information.

The Shibboleth System Is a Solution for the Campus and the User

Because only information (attributes about the person requesting authentication) is exchanged, the Shibboleth system allows institutions with different technology architectures and security systems to easily collaborate without using proxies or managing thousands of external or transitory accounts. It also simplifies the process of integrating a service, such as access to a licensed library resource with campus-based authentication systems. The Shibboleth system can:

- Leverage existing infrastructure (once it's installed, other Shibboleth software-enabled sites can be easily added).

- Facilitate collaboration with other campuses, organizations, and off-campus vendor systems.

- Operate without releasing identity, where appropriate.

Who Is Using the Shibboleth System?

Internet2 and a group of leading campus middleware architects from Internet2 member schools and corporate partners constitute the project and implementation team for the Shibboleth initiative. Organizations collaborating in its development include national and international higher education institutions, their partners, content providers, and government agencies.

- At The Pennsylvania State University during fall semester of 2002, Information Technology Services and the Department of Physics piloted the Shibboleth system. Now in production for more than a year, the Shibboleth system has successfully enabled 1,200 Penn State students enrolled in three physics courses to access resources at North Carolina State University to complete their course assignments.

- The National Science Digital Library (NSDL), funded by the National Science Foundation, uses the Shibboleth system to facilitate seamless access for its patrons and community participants. David Millman, the director of Research and Development at Academic Information Systems at Columbia University and a member of the NSDL Core Integration Team said, "The NSDL has long been committed to the Shibboleth technology because of its scalable, distributed architecture and its privacy protections, both critical goals of the NSDL itself."

During 2003, twenty university campuses and higher education service providers, along with six digital content providers/publishers and three course management vendors/publishers, participated in the Shibboleth Pilot Project. Numerous campuses and higher education associations as well as content, service, and learning management system vendors are working on improvements and enhancements to the Shibboleth system.

"At Ohio State, we believe that the ability to provide trusted authentication across different organizations is an essential requirement for today's course management systems. We're working with other universities, as well as our library, to offer single sign-on capabilities to diverse and distributed student populations with the course management system as the front door to these integrated services."

Steve Acker, *Director of Learning Technologies Research and Innovation at The Ohio State University*

Federations: Sharing Resources across Domains

When a number of organizations join together to use Shibboleth software to share access to resources in a common way, this is called a Federation. The Shibboleth system supports federations by providing scalable methods to manage and distribute configuration and security information among a large number of organizations, and a common vocabulary for user attributes. Internet2 is establishing federations in support of the needs of US Higher Education, and other federations are emerging in other communities.

To Learn More

Visit shibboleth.internet2.edu for information about implementation requirements, software downloads, email lists, and software demonstrations. Contact shib-info@internet2.edu with specific questions.

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www.internet2.edu

Number of Addresses in IPv4

4,294,967,296

World Population (2003 est.)

6,314,000,000

Number of Addresses in IPv6

340,282,366,920,938,463,463,374,607,431,768,211,456

IPv6

ipv6.internet2.edu

IPv6 is the next version of the Internet Protocol, the data packaging and routing standard on which the Internet is based. The current version is IPv4; IPv5 was experimental and was never widely deployed.

IPv6 offers several improvements over IPv4. Most importantly, with 128-bit Internet addresses instead of the 32-bit addresses of IPv4, IPv6 vastly increases the number of addresses available from about 4 billion to about 340 trillion trillion trillion.
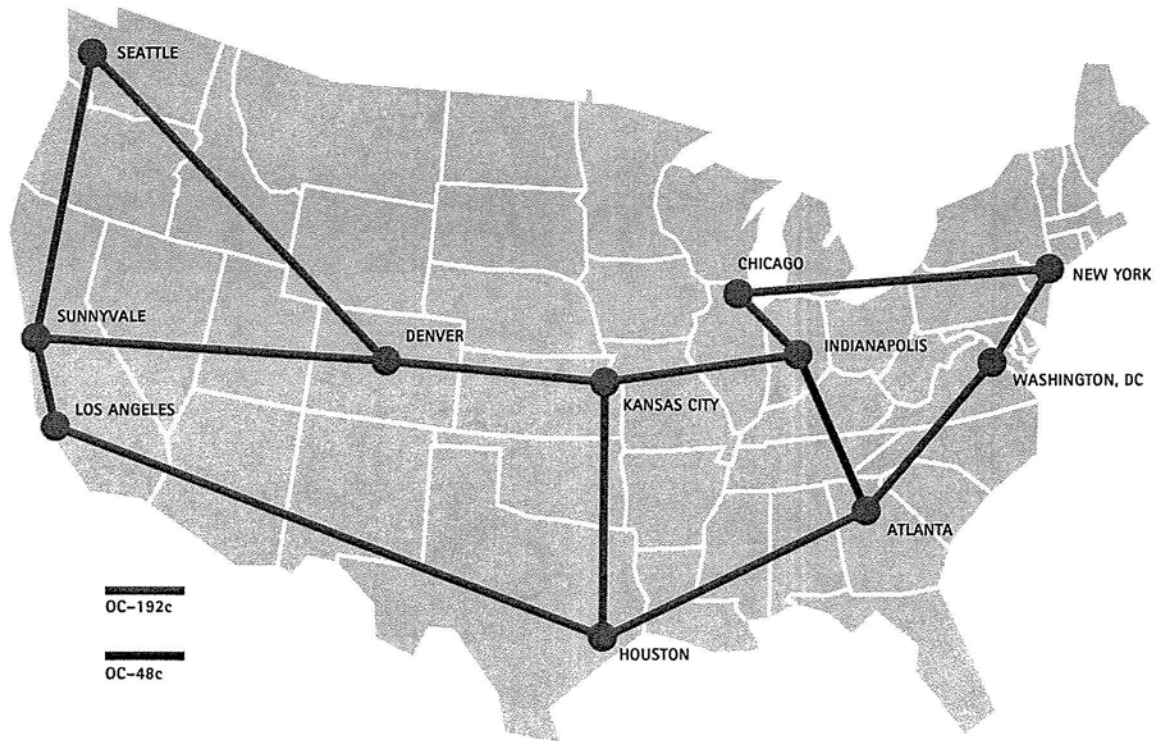
Given the continued rapid growth of the Internet, ensuring an abundance of addresses is crucial. The proliferation of wired and (especially) wireless devices means that in the near future not one or two, but many addresses will be required for each person who uses the Internet. The techniques currently employed to cope with the shortage of IPv4 addresses are reaching their limits, and many of these techniques — such as temporary address assignment and network address translation — compromise engineering principles fundamental to the Internet's success, thus jeopardizing its future growth.

Internet2 is committed to offering world-class IPv6 connectivity to its members, affiliates and partners.

The Internet2 **IPv6 Working Group** coordinates Internet2's IPv6 efforts. The working group discusses and implements IPv6 policies, responds to deployment questions, and disseminates IPv6-related news.

IPv6 hands-on workshops provide opportunities to learn about the IPv6 protocol and how to design, implement and maintain an IPv6 network. All workshop materials, including presentations and lab equipment, are available for Internet2 members, affiliates and partners to use in providing their own regional workshops.

Abilene's Dual-Stack IPv4/IPv6 Network

Map legend:
OC–192c
OC–48c

Cities shown: SEATTLE, SUNNYVALE, LOS ANGELES, DENVER, KANSAS CITY, HOUSTON, CHICAGO, INDIANAPOLIS, ATLANTA, NEW YORK, WASHINGTON, DC

Abilene is a dedicated backbone network for the Internet2 community. Abilene is a dual-stack IPv4/IPv6 network and supports bandwidths of up to 10 Gbps; the network is designed to provide optimal performance to both IPv4 and IPv6 packets. Abilene connects high-performance regional networks to support the work of Internet2 members as they develop advanced Internet applications and the advanced networking capabilities needed to support them; many of these members and regional networks are now deploying IPv6. Abilene also maintains IPv6 peerings with many other US and international backbone networks, helping to secure the future of connectivity for research and education worldwide.

The Abilene backbone is monitored 24 hours a day, 7 days a week by the **Abilene NOC** at Indiana University. Abilene NOC engineers treat IPv6 as they would any production service and are experienced at handling IPv6 issues at the backbone, regional, and campus levels.

The Internet2 Technology Evaluation Centers (**ITECs**) in Ohio, North Carolina, California, and Texas are test facilities for Internet technologies being evaluated for deployment in the Abilene backbone and throughout the Internet2 networking infrastructure. Evaluating IPv6 technologies such as IPv6 routing and IPv6 multicast is a principal focus of the ITECs' work.

Internet2 is working to realize the potential of IPv6 for the global Internet community. Find out more at:

Abilene: *abilene.internet2.edu*
Abilene NOC: *www.abilene.iu.edu*
ITECs: *itecs.internet2.edu*
IPv6 Working Group: *ipv6.internet2.edu*

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Middleware is a layer of software between a network and the applications that use it. Middleware is an infrastructure that manages security, access, and information exchange on behalf of applications to make it easier and more secure for people to communicate and collaborate. It is used both to find people and things, as with directory services, and to keep them confidential, as with security services.
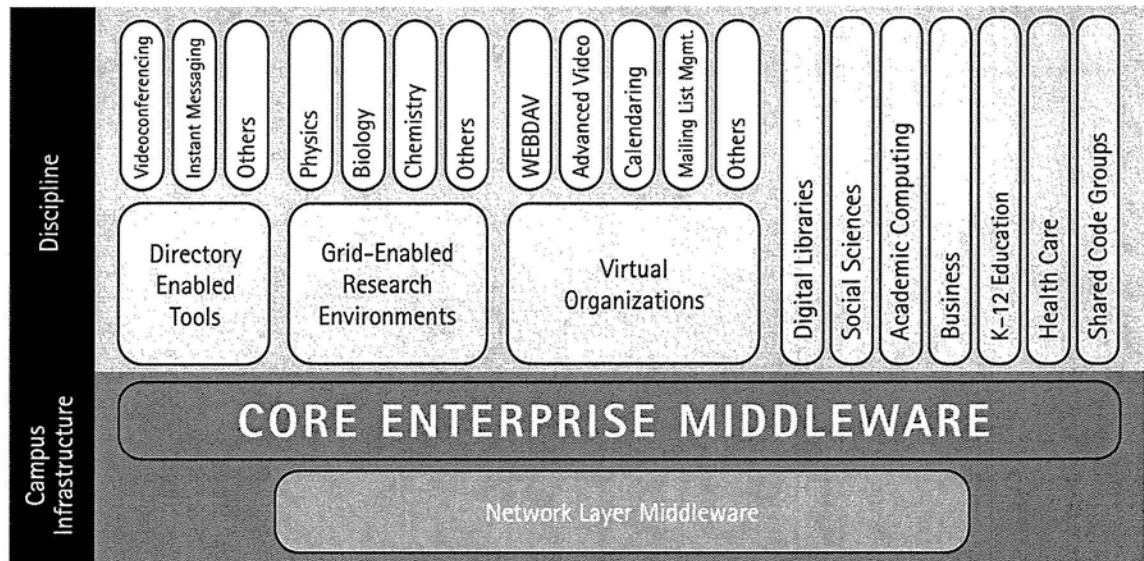
Why Middleware?

The absence of common, standard middleware solutions is a big problem for today's research and education networks. Addressing the opposing challenges of ensuring security and access, availability and privacy, a technology infrastructure—generically called "enterprise middleware"— is emerging throughout higher education, government, and corporate sectors.

Many of the online services and applications that campuses offer have similar requirements, which this infrastructure addresses:

- Are the people using these services who they claim to be?
- Are they members of our campus community?
- Do they have permission to use these services?
- Is their privacy being protected?

Applications either make do without these core middleware functions—in which case usability, security, and efficiency suffer—or applications perform middleware functions themselves, leading to competing and incompatible standards.

What is the Internet2 Middleware Initiative?

The goal of the Internet2 Middleware Initiative is to contribute to the building of an international interoperable middleware infrastructure for research and education.

The Middleware Architecture Committee for Education (MACE), a group of leading higher education IT architects, provides overall direction and vision for the Initiative. Their working agenda is set by campus CIOs and partners and includes:

- Researching and developing architectures, software, methodologies, practices, and standards for campus IT middleware infrastructure.
- Encouraging the establishment of community-based middleware policy and technology infrastructures.
- Working with government, corporate, and other national and international communities to ensure integration.
- Promulgating the findings and deliverables to catalyze deployment across the research and education communities.

Middleware Working Groups

While the vision is supplied by MACE, the research details are addressed by the Internet2 Middleware working groups. MACE forms these as needed to explore specific issues; below is a sampling of the many working groups (with their core enterprise middleware foci).

MACE-Dir (Directories)
The MACE-Dir Working Group researches and develops architectures and common practices to facilitate intra- and inter-institutional information exchange about people and services stored in an enterprise directory.

MACE-Shibboleth (Authentication and Authorization)
The MACE-Shibboleth Working Group develops architectures and corresponding software to support intra- or inter-institutional authentication and authorization for access to restricted electronic resources.

HEPKI-TAG (PKI)
The Higher Education Public Key Infrastructure-Technical Activities Group (HEPKI-TAG) is a collaboration between the Internet2 Middleware Initiative and EDUCAUSE and was formed to investigate technical issues related to the deployment of PKI in higher education.

MACE-WebISO (Authentication)
The MACE-WebISO Working Group investigates "web initial sign-on" (WebISO) software, which leverages campus authentication services to allow users with standard web browsers to authenticate to web-based services across many web servers.

VidMid (Directories and Authentication)
Video Middleware (VidMid) furthers the development of middleware for videoconferencing and related areas and is a collaboration between Internet2 Middleware Initiative and the Video Development Initiative (ViDe). The working group focuses on resource discovery and authentication for point-to-point and multi-point videoconferencing, and similar middleware requirements for video-on-demand, data collaboration, and voice over IP.

Core Enterprise Middleware components enable "transparent use," providing consistent infrastructure for security, privacy and access to protected resources:

- Identity—unique markers of person, machine, service, or group
- Authentication—how you prove or establish your identity
- Authorization—what an identity is permitted to do
- Directories—where an identity's basic characteristics (attributes) are kept
- Public Key Infrastructure (PKI)—set of security technologies that relies on the exchange of electronic credentials called certificates

NSF Middleware Initiative

The Internet2 Middleware Initiative also works in coordination with several other middleware-oriented efforts. The most important of these is the NSF Middleware Initiative (NMI) in which Internet2 partners with EDUCAUSE and the Southeastern Universities Research Association (SURA) under the consortium banner of NMI-EDIT. Funded with the GRIDS Center, these two teams work together on integrating campus and grid research infrastructures.

To Learn More

Visit middleware.internet2.edu for information about working group activities, architectures, implementation practices and guidelines, software downloads, email lists, and software demonstrations.

Contact mw-info@internet2.edu with specific questions.

Abilene

abilene.internet2.edu

The Abilene Network is an Internet2 high-performance backbone network that enables the development of advanced Internet applications and the deployment of leading-edge network services by Internet2 universities and research laboratories across the country. Created by the Internet2 community, Abilene connects regional network aggregation points—known as gigaPoPs—to provide advanced network capabilities to over 230 Internet2 university, corporate, and affiliate member institutions in all 50 states, the District of Columbia, and Puerto Rico. The current network is an OC-192c (10 Gbps) backbone employing optical transport technology and advanced high-performance routers.

Abilene Network Design

OC-192c
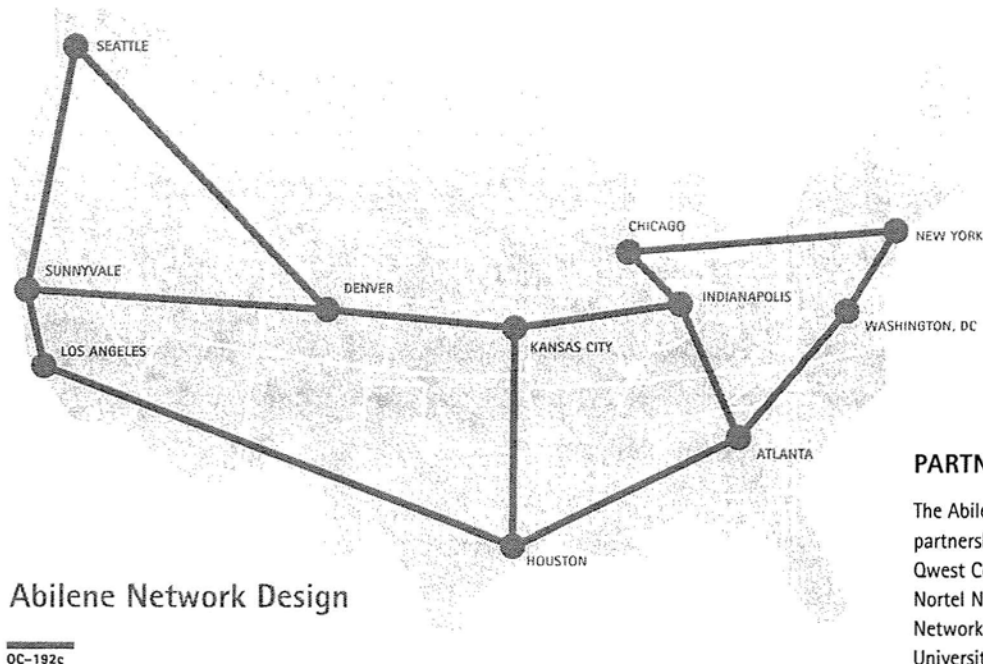
PARTNERSHIPS

The Abilene Network is a partnership of Internet2, Qwest Communications, Nortel Networks, Juniper Networks, and Indiana University.

Abilene Goals

Abilene Community

Global Research Interconnectivity

Abilene Observatory

Advanced Network Applications

Abilene Goals

The goals of the Abilene Network are to provide an advanced backbone in support of:

- Cutting-edge applications developed using innovative, experimental techniques and requiring high-performance network services not available on existing commercial networks.
- The deployment and testing of advanced services, including multicast, IPv6, measurement, and security, which are generally not possible on the commodity Internet.
- Connectivity to other research and education networks throughout the world, including the U.S. federal research networks, thus enabling the international research community to collaborate in new ways.
- Access for researchers to a rich set of network characterization data collected in a high-performance networking environment supporting new and innovative applications.

ADVANCED SERVICES AND CAPABILITIES

Advanced Internet services are an important aspect of the Abilene Network, and include:

- Multicast
- Native IPv6 Support
- Measurement
- Security
- Raw HDTV Streaming – 1.5 Gbps
- Bulk Data Transfer
- Interactive Collaboration
- Grid Computing

Abilene Community

The Abilene community includes three general levels of participation:

- Primary Participants — Internet2 members, including research universities and collaborating federal and corporate research laboratories located in the U.S.
- Sponsored Participants — Collaborating partners of Internet2 university members (e.g., small laboratories, museums, clinical research centers) requiring access to advanced networking.
- Sponsored Educational Group Participants (SEGP) — Aggregations of state education networks connecting the K-12 community, baccalaureate and community college networks, and libraries.

Global Research Interconnectivity

The Abilene Network provides connectivity for participating institutions to over 40 other research and education networks, both within the United States and internationally. Abilene also serves as an International Transit Network so that two international peers can transit Abilene for interconnectivity when required.

The Abilene Observatory

http://abilene.internet2.edu/observatory

The Abilene Observatory supports the network research and advanced network engineering communities through the collaborative sharing of the vast amounts of network performance information gathered within the Abilene Network and the facilitation of innovative network experiments deep within the core of a national backbone network. The Observatory effort has two essential components:

- An accessible, correlated archive of data collected by the Abilene project team using dedicated measurement servers in each of the Abilene router nodes; and
- The support of affiliated research projects through the placement of experimental servers and other measurement equipment in these nodes.

Advanced Network Applications

The development of advanced applications is an essential component of Internet2. The Abilene Network provides a platform for the deployment of such applications.

Remote Media Immersion

http://imsc.usc.edu/rmi/

Tremendous network resources are required to capture, stream, and render the high-resolution, big-screen digital video and high-fidelity, multichannel audio needed to create a seamless, teleimmersive presence. Researchers at the NSF-funded University of Southern California Integrated Media Systems Center are using Remote Media Immersion (RMI), which combines several breakthrough Internet technologies, as a test bed to deliver immersive experiences over the Abilene Network. Their experiments have yielded the error-free transmission of multiple synchronized data streams with sustained data rates as high as 60 Mbps.

NEES Consortium

http://www.nees.org

NEES Consortium, Inc. is the National Science Foundation (NSF)-funded, non-profit consortium charged with overseeing the George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES). NEES includes 15 large-scale, experimental sites, which feature such advanced tools as shake tables, centrifuges, a tsunami wave basin, and field-testing equipment. Distributed across 10 states, these facilities are linked to a centralized data pool and earthquake simulation software, bridged together by the advanced capabilities of Internet2's Abilene Network to form a national virtual earthquake engineering laboratory. The NEESgrid system allows off-site researchers to interact in real time with any of the networked sites.
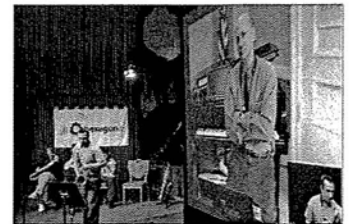
INTERNET₂®

www.internet2.edu

The National Internet2 K20 Initiative brings together Internet2 member institutions and innovators from primary and secondary schools, colleges and universities, libraries, and museums to extend new technologies, applications, middleware, and content to all educational sectors, as quickly and connectedly as possible. As of early 2005, there were 34 state K20 networks participating, enabling about 30,000 K20 institutions—including 23,388 K12 schools, 2360 public libraries, 594 community colleges, 852 four-year colleges and universities, and 74 museums, zoos, aquariums, and science centers—to connect to Internet2 advanced networks.

Experiences and Expertise

International Learning Communities
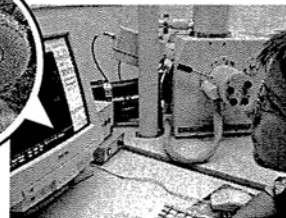
Rich Multi-Media Digital Libraries

Remote Instrumentation

Creating New Knowledge

Creating New Opportunities

My K2o
Community

Lewis and Clark Then and Now: Linking the Trail to America's Students
School District of Clayton, MO
Apple Computer

http://www.ali.apple.com/lewisandclark

From 2003 to 2006, the United States will commemorate the bicentennial of the Corps of Discovery's historic journey across America. Throughout the 2003-2006 school years, Lewis and Clark Then and Now: Linking the Trail to America's Students will follow various re-enactment groups as they retrace the three-year voyage of the Corps of Discovery. Many aspects of Internet2 are involved—including the Internet2 Commons H.323 Videoconferencing Service, the National Internet2 K20 Initiative, and the ResearchChannel Working Group—enabling students in classrooms nationwide to retrace Lewis and Clark's journey and understand how it shaped America today.

Music Bridges: K-12 Faculty-Driven Music Programs
Manhattan School of Music
St. Clair County Intermediate School District, MI

http://www.msmnyc.edu/special/video

Manhattan School of Music's distance learning program is partnering with Michigan's St. Clair County Regional Educational Service Agency to present music programs delivered via interactive videoconferencing over Internet2 advanced networks. St. Clair County, which includes 57 schools across 7 school districts, will receive offerings such as American Composers, A Personal Introduction to Opera, and the type of custom telementoring sessions that require the high-fidelity, broadcast-quality streaming audio and video available over Internet2. By eliminating the barriers of time and distance, Manhattan School of Music's faculty and student teaching artists can extend their expertise to students and audiences around the country.

ImagiNations Remote Instrumentation Project
Lehigh University

http://www.lehigh.edu/~inimagin/

The ImagiNations project introduces K-12 students to electron microscopy and nanotechnology. The Center for Advanced Materials and Nanotechnology (CAMN) at Lehigh University uses Internet2 to offer K-12 students real-time remote access to the XL30 ESEM (environmental scanning electron microscope). Scale and surface area animations are available for the students' interaction, along with interactive image magnifications on the project website.
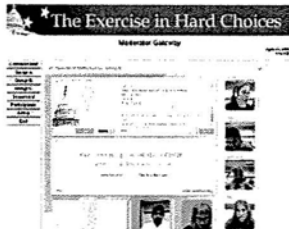
The Exercise in Hard Choices

The University of Akron
Beachwood City School District, OH
Plain Local School District, OH
St. Clair County RESA, MI

http://www.crfb.org/html/exercise.htm

For over 20 years, the Committee for a Responsible Federal Budget has administered *An Exercise in Hard Choices*SM, an interactive budget exercise, in a face-to-face, "traditional" format. The Exercise gives participants the opportunity to role-play members of Congress as they debate spending and revenue options in small groups and arrive at a final federal budget for the year. The University of Akron has been engaged by the U.S. Department of Education for three consecutive years to develop, test, and evaluate electronic versions of the Exercise, making use of the low latency and end-to-end performance capabilities of Internet2 to facilitate high quality video connections among distant participants.

Megaconference Jr.

Chester County Intermediate Unit, PA
MAGPI
St. Clair County RESA, MI
Several International Collaborators

http://megaconferencejr.org

Megaconference Jr. is the first student-led international videoconference learning event for K-20 schools. This all virtual H.323 videoconference brings together students and teachers from around the world to showcase curricular project initiatives, increase cultural awareness and broaden understanding of the role advanced networks have in the 21st century world. In Megaconference Jr., students are involved in all aspects of the conference including planning, technical implementation and script writing.

A primary goal of Megaconference Jr. is for schools to form sustained collaborative projects to extend the learning environment to the world outside the classroom.

Microscope Imaging Station

Exploratorium

http://www.exploratorium.edu/imaging_station

Located in San Francisco, the Exploratorium features hundreds of science, art, and human perception exhibits. The Exploratorium is a leader in the use of advanced networks to extend the outreach of museums as educational centers. The Exploratorium's Microscope Imaging Station gives museum visitors a unique opportunity to control research-grade microscopes and view stunning images of biological processes.
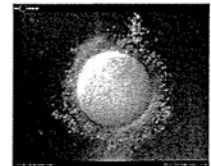
The web site provides a large and growing collection of interactive high-resolution images and DVD-quality videos. The Exploratorium is developing a virtual microscope and activities for classroom use.

Immersion Institute

Mystic Aquarium
Monterey Bay National Marine Sanctuary
NOAA
VBrick

http://mysticaquarium.org/

Visitors to Connecticut's Mystic Aquarium can immerse themselves in an underwater world 3,000 miles away by remotely controlling underwater cameras in California.

Using interactive consoles at the Mystic Aquarium's Immersion Institute, visitors control three video cameras on an underwater submersible in the Monterey Bay National Marine Sanctuary, the largest U.S. marine sanctuary. Using VBrick Systems MPEG-2 encoder/decoders, the live video is encoded into DVD-quality MPEG-2 and sent at an average rate of 6 Megabits per second (Mbps) to the University of California, Santa Cruz, where it travels across Internet2 high-performance networks to the University of Connecticut and on to the Mystic Aquarium.

Getting Involved

The Internet2 K20 website has what you need to get engaged — project descriptions, people directories, collaboration tools, articles, news and events, and FAQs.
http://k20.internet2.edu

www.internet2.edu

Internet2 health science applications are enabling breakthroughs in medical education, research, and clinical practice. Doctors are gaining access to specialists for remote consultations, students are learning anatomy with the support of new tools and technologies, and smart databases are assisting with diagnosis and knowledge sharing among researchers. All of these advancements are made possible by Internet2's advanced networks and the emerging technologies that facilitate the secure transfer of large data sets and access to shared resources.

PathMiner: Image Guided Decision Support Project

UNIVERSITY OF MEDICINE & DENTISTRY OF NEW JERSEY – ROBERT WOOD JOHNSON MEDICAL SCHOOL
THE CANCER INSTITUTE OF NEW JERSEY

http://www.umdnj.edu
http://www.cinj.org

As the amount of information archived digitally worldwide continues to grow, it becomes increasingly difficult to index information for future relocation or retrieval. This is an especially challenging problem for images, which are often indexed using a single text-based label. Researchers at the University of Medicine & Dentistry of New Jersey, Rutgers University, and the University of Pennsylvania have developed content-based image retrieval tools for diagnostic pathology. The NIH-funded *PathMiner* system that they have developed is a web-based set of tools for interactive telemedicine, intelligent archiving, and automated decision support in pathology. By utilizing Internet2's advanced networks, the *PathMiner* system enables individuals to submit query images from local or remote computers—or robotic or virtual microscopes—to search engines that automatically identify and retrieve digitized pathology data of statistically-similar tissues from within distributed databases. Eventually, the system will also support the integration of high-resolution video streaming across Internet2 advanced networks.
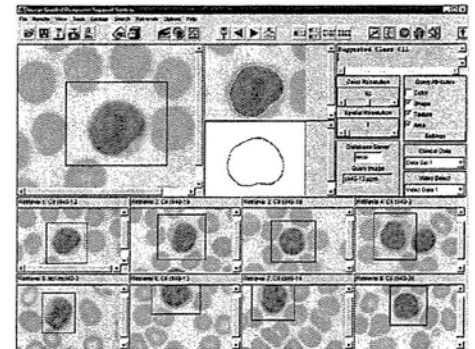

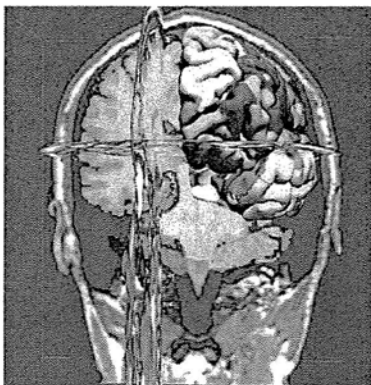Image courtesy of UMDNJ – Robert Wood Johnson Medical School

Image courtesy of BIRN

Biomedical Informatics Research Network

INTERNET2 UNIVERSITY MEMBER BIRN PARTICIPANTS

http://www.nbirn.net

Drawing upon the expertise and technologies available at universities, hospitals, and other institutions, the Biomedical Informatics Research Network (BIRN) is building an infrastructure of networked high-performance computers, data integration standards, and other emerging technologies, to pave the way for medical researchers to transform the treatment of disease. Launched in 2001 as an initiative of the National Institutes of Health's National Center for Research Resources, the BIRN is prototyping a collaborative environment for biomedical research and clinical information management.

BIRN leverages Internet2's advanced networking infrastructure to enable collaboration and data sharing for biomedical research. With Internet2 production resources and networking facilities like the OptIPuter, BIRN is able to respond to the current and future needs of the biomedical research community. This cyberinfrastructure encourages biomedical scientists and clinical researchers to make new discoveries by enabling sharing, analysis, visualization, and data comparisons across laboratories. The growing BIRN consortium currently includes over 20 Internet2 member organizations and involves more than 40 research groups from universities and hospitals located in the United States and United Kingdom interconnected by Internet2 advanced networks and their international partner networks, which provide a stable backbone for all distributed data within the BIRN.

Remote Stereo Viewer

STANFORD UNIVERSITY

UNIVERSITY OF WISCONSIN-LACROSSE

http://summit.stanford.edu/

http://www.visu.uwlax.edu/NGI/RSV.html

Medical students at Stanford University are using a new educational tool called Remote Stereo Viewer (RSV) to complement their traditional gross anatomy coursework. The tool was developed through a collaboration of Stanford's SUMMIT lab and the Computer Science department at the University of Wisconsin-La Crosse, and was partially funded by the National Library of Medicine. Internet2 advanced networks make it possible for the RSV application to enable medical educators and students in different locations to collaboratively view three-dimensional interactive high-resolution stereo photographs of anatomical structures. The selected anatomical specimen can be viewed in various stages of dissection, which enables students to move between the layers and offers them a better understanding of the intricacies and complexity of the feature being studied. To develop this tool, rotated sequences of stereo image pairs were produced by volumetric rendering of the visible female and by dissecting and photographing a cadaveric hand. The images are stored on a server and individually downloaded to a workstation on demand. Individual users take the role of "leader" or "follower" to navigate through the specimen together in real time, creating a virtual classroom between users at different workstations and different locations. RSV requires the high bandwidth of Internet2's advanced networks to accommodate the size of the high-resolution stereo images. The application also utilizes multicast, allowing participants at all workstations to simultaneously view the specimen navigation occurring at one workstation.
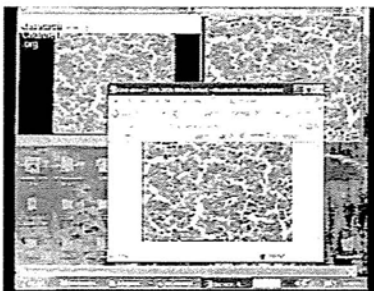
DVTS for Telemicroscopy

UNIVERSITY OF PENNSYLVANIA

http://www.uphs.upenn.edu/path

Pathologists at the University of Pennsylvania Health System have been experimenting with Digital Video Transport System (DVTS) for high-quality video telepathology and telemicroscopy over Internet2 advanced networks. This simple and inexpensive method of transmitting high-quality video and audio enables doctors to perform consultations at remote hospitals where there is no pathologist on site, to offer second-opinion consultations, and to provide distance education. In Philadelphia, it is used by pathologists at the three hospitals that comprise the University of Pennsylvania Health System to perform real-time clinical case consultations. DVTS uses 30 Mbps uncompressed video to provide high-quality images with low latency. DVTS can also be used in multicast mode to allow three or more sites to participate in a single conference. DVTS is one of the principal areas of activity of the Internet2/ResearchChannel Working Group's BigVideo project group, which explores high-quality on-demand and streaming video applications.

Center for Surgical Innovation

UNIVERSITY OF CINCINNATI

http://surgery.uc.edu/csi

The Center for Surgical Innovation (CSI) at the University of Cincinnati was established to develop, assess, and disseminate new technologies in biomedical and surgical care. They have been at the forefront of telesurgery and surgical robotics, and are pioneering the application of advanced networking to these technologies. CSI and its partners modified the daVinci Surgical System—currently the only clinically supported surgical robotic system—to create a system capable of transcontinental stereoscopic robotic surgical intervention. Using Internet2's advanced networks, researchers are improving the system's image fidelity and decreasing latency, jitter, and packet loss in order to meet the high standards that clinical use demands.

Providing surgeons the ability to mentor and perform procedures from remote locations will have a profound impact on the quality and type of care provided to soldiers on the battlefield, astronauts in space, undersea researchers, and even patients in remote geographic locations.
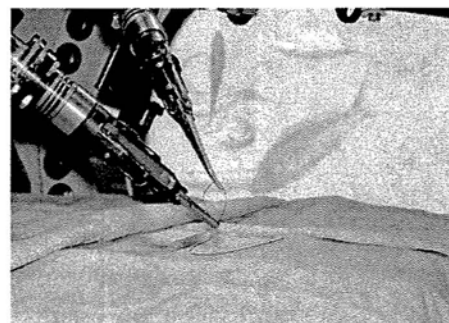
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Internet2 Applauds New FCC Program To Build Advanced Internet Infrastructure Dedicated To Healthcare

FCC Pilot Program to Facilitate Creation of Regional Health Networks and Enable Connections to Internet2's Nationwide Advanced Research and Education Network

WASHINGTON D.C. - September 26, 2006 - Internet2 applauds the Federal Communications Commission's (FCC) action today to create a pilot program that will help public and non-profit health care providers establish state and regional broadband networks dedicated to health care services as well as provide funding for these networks to connect to Internet2's nationwide advanced research and education network. This new program will catalyze the formation of a ubiquitous advanced healthcare network that will serve the country's national interest by improving citizens' access to first class healthcare services, resources and research.

"This program created by the FCC represents a significant step towards realizing the potential of advanced Internet technology to enhance the quality and availability of healthcare services by improving access to medical expertise, facilitating the flow of information for research, and streamlining care processes and costs," said Dr. Michael McGill, who is responsible for Internet2's health sciences program. "Internet2 looks forward to working with our regional research network connectors and partners, as well as health organizations throughout the country, to understand their specific networking requirements and to rapidly provide the necessary capabilities to support this important work."

By linking high-speed state and regional research and education networks, the nationwide Internet2 backbone now connects more than 46,000 research and education institutions with high-performance, highly-reliable networking. Providing connectivity to health networks across the country is a natural extension of Internet2's existing network capabilities and complements its members' ongoing work in the health sciences arena.

Today, Internet2 members, including the National Institutes of Health (NIH), the Healthcare Information and Management Systems Society (HIMSS), Charles R. Drew University of Medicine and Science, Howard Hughes Medical Institute, and the Ruth Lilly Health Education Center together with over 120 other connected healthcare organizations and medical schools, work collaboratively to develop and deploy advanced Internet technologies in support of health sciences. This collaborative research has yielded significant results in improving the way students, doctors, and patients interact, including the development of virtual surgery technologies that allow medical students to learn skills from experts all over the world; telemedicine applications that can provide patients in rural areas access to doctors from major medical facilities; and identity management technologies that can provide privacy control for patients' medical records.

For more information about the FCC pilot program visit: http://www.fcc.gov or
http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-267605A1.pdf

About Internet2
Internet2 is the foremost U.S. advanced networking consortium. Led by the research and
education community since 1996, Internet2 promotes the missions of its members by providing
both leading-edge network capabilities and unique partnership opportunities that together
facilitate the development, deployment and use of revolutionary Internet technologies. Internet2
brings the U.S. research and academic community together with technology leaders from
industry, government and the international community to undertake collaborative efforts that
have a fundamental impact on tomorrow's Internet. For more information:
http://www.internet2.edu/

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202.331.5345

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Focused on Creating an Advanced and Interoperable Medical Network, HIMSS and Internet2 Announce Collaboration

The two organizations will leverage each other's expertise to explore the viability of an independent and logically interconnected medical network in the United States

CHICAGO, Ill. and ANN ARBOR, Mich. - August 1, 2006 - The Healthcare Information and Management Systems Society (HIMSS) and Internet2 announced today that the two organizations have created a partnership to explore the development of a secure, reliable and advanced networking solution for the transmission of medical information, messages and images throughout the broad healthcare industry.

The two organizations are exploring a new network designed to offer the health sciences and healthcare sectors a private and secure medium for exchanging health information. A next-generation architecture built to meet federal regulatory requirements, this new network may also have value to offer in the work of the National Health Information Network (NHIN).

This ground-breaking collaboration is a natural extension for both not-for-profit organizations. Through a membership of 20,000 individuals, 45 chapters, and more than 300 corporations representing millions of employees, the HIMSS mission focuses on the betterment of healthcare through the most effective use of information technology and management systems. Internet2, the U.S.'s advanced networking consortium led by 208 U.S. university members in partnership with over 100 industry and government members, works to develop and deploy advanced networks, applications and resources.

"HIMSS and our members look forward to this collaboration with Internet2," said H. Stephen Lieber, HIMSS president/CEO. "The synergies between HIMSS and Internet2 brought our organizations together to consider and evaluate the feasibility of establishing a network that would meet the evolving needs of the biomedical and healthcare delivery community."

Since 1999, Internet2 has operated an advanced nationwide network that supports leading-edge Internet technology development for the research and academic community. Internet2 recently announced a major upgrade to this network to provide members ten times the capacity and speed of its current infrastructure. In addition, the Internet2 community has successfully developed important middleware technologies to address critical issues in authentication and authorization in order to enable active privacy management. Through this partnership, HIMSS and the Internet2 community will work closely together to leverage these leading-edge technologies to explore development of brand new capabilities that meet the specific security and privacy needs of the healthcare industry.

"The research and education community has long understood the potential for leveraging advanced Internet technology to enhance the healthcare industry's ability to serve the public's needs, to improve the flow of information for research, to streamline care processes and to enable cost savings," said Douglas Van Houweling, Internet2 president and CEO. "Our partnership with the HIMSS community is a major step forward in realizing this vision.
Together we will work to create a new state-of-the-art platform for biomedical research, education and clinical practice on a national scale."

Through the partnership, four working groups have been established to explore the requirements and capabilities needed to create an advanced medical network during the next year. HIMSS and Internet2 will join each other's organizations. Members of both organizations will also join each of the four working groups, which include:

- Identity Management that will allow the identification and authentication of individuals regardless of their physical location. - Privacy & Security that will focus on the tools and techniques that will assure the privacy and security of the information that travels on the network. - Biomedical (Health Sciences and Healthcare) Education that will focus on meeting the unique needs and accessing the resources required for biomedical education.
- Telehealth that will focus on the implications for clinical practice when a reliable advanced network is available.

In addition, members of both organizations will work for the development and implementation of the network with other partnerships and collaborations, including Integrating the Healthcare Enterprise (IHE).

About HIMSS

The Healthcare Information and Management Systems Society (HIMSS) is the healthcare industry's membership organization exclusively focused on providing leadership for the optimal use of healthcare information technology (IT) and management systems for the betterment of healthcare.

Founded in 1961 with offices in Chicago, Washington D.C., and other locations across the country, HIMSS represents more than 20,000 individual members and over 300 corporate members that collectively represent organizations employing millions of people. HIMSS frames and leads healthcare public policy and industry practices through its advocacy, educational and professional development initiatives designed to promote information and management systems' contributions to ensuring quality patient care.

About Internet2

Led by more than 200 U.S. universities, working with industry and government, Internet2 develops and deploys advanced network applications and technologies for research and higher education, accelerating the creation of tomorrow's Internet. Internet2 facilitates the kinds of dynamic partnerships among academia, industry, and government that helped foster today's Internet in its infancy. For more information about Internet2 network capabilities, visit http://networks.internet2.edu.

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Internet2 applications enable collaboration among people and shared, interactive access to information and resources in ways not possible on today's Internet. Interactive collaboration, real-time access to remote resources, shared virtual reality, and large-scale, multi-site computation and data mining are examples of just some of the high-performance networking applications that researchers at Internet2 member universities are developing and using today.
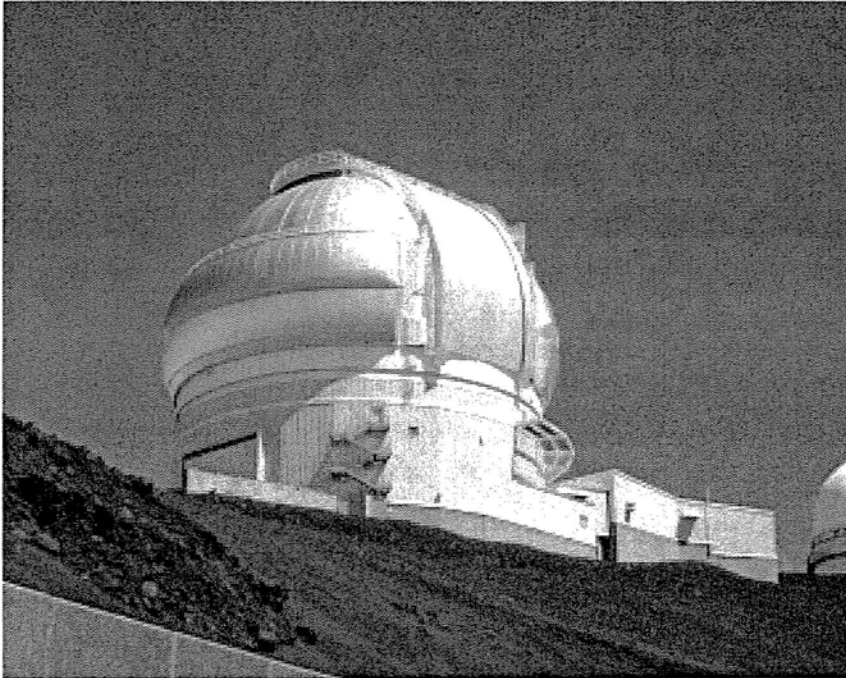
Remote Instrumentation

Remote Instrumentation

Interactive Collaboration

Distributed Computing

Networked Virtual Reality

The Gemini Observatory
Association of Universities for Research in Astronomy

http://www.gemini.edu/

The Gemini Observatory is the result of a multi-national project to build twin 8.1 meter astronomical telescopes in Hawaii and Chile, making the skies in both the northern and southern hemispheres fully accessible to astronomers. High-performance networks enable these mountaintop telescopes to be operated remotely, in real-time, by astronomers in sea level-based control rooms. The high-performance connection also allows scientists to collaborate via videoconferencing, and will enable the observatories to share more of their findings with the public through techniques such as virtual observatory tours and live video to museums, planetaria and classrooms worldwide. Eventually, astronomers with access to Internet2 high-performance networks, in conjunction with international network partners, will be able to 'observe' using the Gemini telescopes from authorized remote sites, without having to travel to Hawaii or Chile.

The nanoManipulator
University of North Carolina at Chapel Hill

http://www.cs.unc.edu/Research/nano/
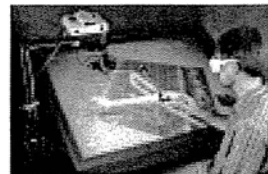
The nanoManipulator is an interface to scanning probe microscopes (SPM) allowing users to see, feel, and manipulate samples ranging in size from DNA to single atoms. The nanoManipulator allows the user to control the SPM, view interactive 3D visualizations of the data, and feel the shape of the sample through a force-feedback device. A nanoManipulator can be used collaboratively by scientists in a "virtual laboratory" environment that allows remote access to a shared microscope and previously collected data. During collaboration, the nanoManipulator transfers video and system control data—all having different bandwidth, loss, and latency (delay) requirements. In contrast to some applications that have "bursty" bandwidth demands, the typical scientific experiment using the nanoManipulator lasts for many hours, creating a long-lived high demand on the network.

Interactive Collaboration

The Access Grid
Argonne National Laboratory

http://www.accessgrid.org/
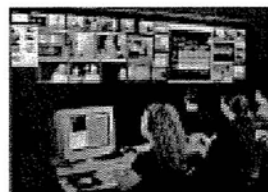
Large-scale scientific and technical collaborations often involve group-to-group interactions with multiple teams working together. The goal of the Access Grid project is to explore and support the requirements of group-to-group interactions across the computational grid. The Access Grid consists of large-format multimedia display, presentation, and interaction software environments; interfaces to grid middleware; and interfaces to remote visualization environments. Access Grid nodes are "designed spaces" that support the high-end audio/video technology needed to provide a compelling and productive collaborative experience. By providing access to these resources, the Access Grid supports large-scale distributed meetings, seminars, lectures, tutorials, and training.
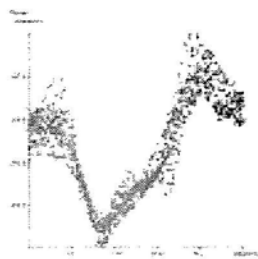
Distributed Computing

National Scalable Cluster Project
University of Illinois at Chicago
University of Pennsylvania

http://www.ncdm.uic.edu/
http://nscp.upenn.edu/

The National Scalable Cluster Project (NSCP) has pioneered the application of cluster computing and high performance wide area networks to a variety of problems in data mining and data intensive computing. Using a testbed called the Terabyte Challenge, the NSCP develops the next-generation tools and standards to manage and mine massive (terabyte to petabyte) collections of data, specifically those that are geographically distributed. The Terabyte Challenge has been used as an Interoperability testbed for the development of the Predictive Model Markup Language (PMML) and has also been used in the development of DataSpace, an infrastructure to explore and mine remote, distributed data in real-time. Shown here is a graphical representation of climate data obtained using the DataSpace Transfer Protocol (DSTP). In this plot of ozone (an attribute) versus latitude (Universal Correlation Key) we are able to see the distribution globally.

Grid Physics Network
University of Chicago
University of Florida

http://www.griphyn.org/

The Grid Physics Network (GriPhyN) collaboration is a team of experimental physicists and information technology researchers who are implementing the first petabyte-scale computational environments for data intensive science. Using Internet2 high-performance networks, GriPhyN will allow geographically dispersed extraction of complex scientific information from massive datasets, provide access to large-scale computational resources, and enable collaboration among worldwide scientific communities. GriPhyN will initially give scientists access to the vast amounts of data that will flow from four large-scale physics and astronomy experiments. GriPhyN will be capable of storing 10 petabytes of data. In addition to the Abilene network, other high-performance networks, including ESnet, NREN, I-WIRE, and international connections through STAR TAP and StarLight, will be used to share data throughout this globally distributed community of scientists.
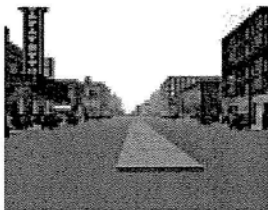
Networked Virtual Reality

Virtual Harlem
University of Missouri – Columbia
Central Missouri State University
University of Illinois at Chicago

http://www.evl.uic.edu/cavern/harlem/

Virtual Harlem is a virtual reality environment originally developed in collaboration with University of Missouri-Columbia to supplement African American literature courses at Central Missouri State University. Students are able to step through a virtual 'portal' to the 1925–1935 New York Harlem Renaissance to navigate the city streets, interact with key figures, and listen to music written and popularized during the era. More recently, the University of Illinois at Chicago's Electronic Visualization Laboratory translated the Harlem experience to a fully immersive CAVE environment, establishing an experimental testbed for a diverse group of educators and researchers. Virtual Harlem has also been deployed as the educational component of a Harlem, New York project to bring high-speed networking to five community technology centers offering under-served communities access to hardware and software.

TIDE2
University of Illinois at Chicago

http://www.evl.uic.edu/cavern/TIDE/

Image courtesy of the Electronic Visualization Laboratory, University of Illinois at Chicago

Tele-Immersive Data Explorer 2 (TIDE2) is a tele-immersion tool that allows distantly located scientists to query and visualize large, multi-dimensional datasets. It features out-of-core memory management and playback tools, and is supported by CAVERNsoft, a cross-platform tele-immersion toolkit for the Grid developed at the University of Illinois at Chicago's Electronic Visualization Laboratory. TIDE2 is designed to be a reusable framework to facilitate the construction of other domain-specific data exploration applications challenged with the problem of having to visualize massive datasets.

INTERNET2®

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Some of the largest consumers of advanced networking on campuses are not in the physics, engineering or computer science departments. Using high-capacity infrastructure to create global stages, enable remote instruction, allow participatory discovery, and open access to rich collections of media–Internet2's Arts & Humanities communities are redefining how they create, teach, perform, and collaborate.

PERFORMANCE

Photo courtesy of the University of Texas at Austin

The Miró Quartet: Live & Virtual

http://arts.internet2.edu/fall2004-perfevent.html

During the Fall 2004 Internet2 Member Meeting, an evening performance event, *The Miró Quartet: Live &Virtual,* showcased the use of cutting-edge networking and streaming technologies, and featured the world-renowned Miró Quartet, a group comprised of University of Texas at Austin faculty. The event took place in two auditoriums with the audience switching venues during intermission. In the first auditorium, the audience saw and heard the string quartet in person. In the second, the audience saw the performance via real-time streaming High Definition Television (HDTV) and 10.2 channel immersive sound technology, developed by the Integrated Media Systems Center at the University of Southern California (USC). The 10.2-channel audio, projected over 26 speakers, allowed engineers to simulate how sound from an in-person performance reflects off acoustic surfaces in three dimensions. The HD stream featured four parallel channels, which captured each of the performers on stage individually. The performance served as a prototype for performing for an audience in two smaller auditoriums.

Telematic Choreography

http://dance.fsu.edu/telematics/events/ wsu3304.html

Photo courtesy of Maggie Allesee Department of Dance, WSU

The Florida State University (FSU) Department of Dance used Internet2's Abilene Network to provide long-distance coaching for dance students at the Wayne State University (WSU) Maggie Allesee Department of Dance. This interactive rehearsal session enabled internationally renowned choreographer and FSU Professor Jawole Zollar to observe and coach WSU dancers using interactive video and audio as they rehearsed excerpts from her work *Hair-Stories.* This telematic dance coaching session was the inaugural event of the Black Box Studio, a technology-enhanced FSU facility for video documentation, telematic research, and multimedia theater design. "Telematics"–a term created to describe the blending of computers and telecommunications technologies–provides a set of applications often used in the delivery of distance education. According to FSU Assistant Professor Tim Glenn, faculty researcher in dance telematics, "Advanced network technology opens the door to a whole new approach for how we create, teach, and perform dance works. As a result, the art of dance is redefined by incorporating the tools of new technologies into the dancers' experience. "

Photo courtesy of Arctic Region Supercomputing Center

Art on the Grid

http://www.uaf.edu/news/featured/05/artgrid/

Instead of a physical location that is "somewhere," the Access Grid provides a virtual location that is "everywhere." Using the Access Grid, an ensemble of multimedia large-format displays and interactive visualization environment, the University of Alaska Fairbanks presented musical artist Valerie Naranjo to 26 locations around the world. Valerie is the percussionist for the Saturday Night Live Band and Drum Principal and Arranger for the Broadway production of *The Lion King.* During her session, she performed on the gyil (pronounced "Jee-lee", an African xylophone), the marimba, sang Native American songs and lectured about her music. She also directed remote participants in call and response singing, and ended the clinic with a Q&A session. Students and faculty from five university percussion programs participated: University of Alaska Fairbanks, University of New Mexico, University of South Dakota, University of Maine, and Jackson State University. Other participants included public school students, teachers, and music enthusiasts in the Access Grid community. This project was coordinated through "Art on the Grid", a collective of visual, media, and musical artists/educators who are developing productions on the Access Grid in order to explore its strengths, weaknesses and inherent potential. For more information about Art on the Grid, visit http://arts.internet2.edu/files/Percussion-and-Internet.pdf

Return to the Titanic

http://www.clevelandart.org/educef/titanic/html/

Photo courtesy of NOAA

The Cleveland Museum of Art provided a live portal to a unique interdisciplinary experience, *Return to The Titanic.* A series of satellite broadcasts featured live video from the depths of the Atlantic Ocean chronicling Dr. Robert Ballard's return expedition to the Titanic. Serving as the Ohio location, the Cleveland Museum of Art created a bridge for its community to the historical, archaeological, and scientific significance of the Titanic site.

A satellite system on the expedition's research vessel sent a real-time stream to VBrick Systems networked video appliances, located at Mystic Aquarium and Institute for Exploration in Connecticut, and then streamed live in MPEG-2 and MPEG-4 video formats over the Abilene Network to the Cleveland Museum of Art where the program was supplemented by an special overview of works of art reminiscent of the period.

Transatlantic Master Class

http://www.nws.edu

Photos by Fabio Bisi

The 2005 GARR conference in Pisa, Italy—hosted by GARR, the Italian Academic and Research Network—invited members of the Internet2 Arts and Humanities community to help stretch the boundaries of technology-enabled, simultaneous, remote learning and teaching. Technical teams from GARR and the New World Symphony created virtual studio space for viola maestro, Hillary Herndon, at the New World Symphony, and viola student, Anna Simeone, from the Conservatory of Music in Pisa. Bridging languages through translators and distance through technolgy, student and teacher interacted during this live musical exchange. The broadcast, the first of its kind between Europe and the US, used two laptop computers: one receiving the 30 Mbps NTSC signal from Miami and converting it to PAL, the other sending the outgoing PAL signal to Miami at 30 Mbps where it was decoded using DVTS software, resulting in an aggregate bandwidth of 60 Mbps. In addition to the conference attendees on site, 170 viewers attended by netcast.
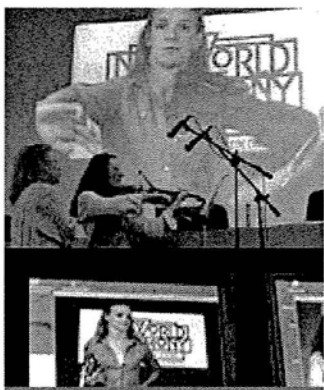
The EVIA Digital Archive

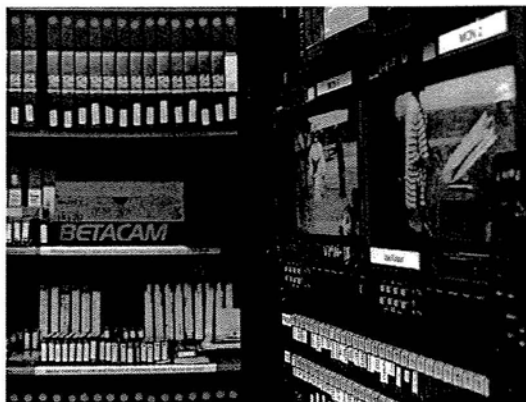*http://www.indiana.edu/~eviada/*

Photo courtesy of R. Thomas Bray, Digital Media Commons, University of Michigan

While most research happens in libraries and archives, ethnomusicologists depend on the products of "fieldwork" for their study. World music events rarely involve only the sound of music, but many additional facets of creative communication. Video recordings, because of their ability to capture not only sound but the multiple facets of creative communication that surround it, are regarded as the recording tool of choice.
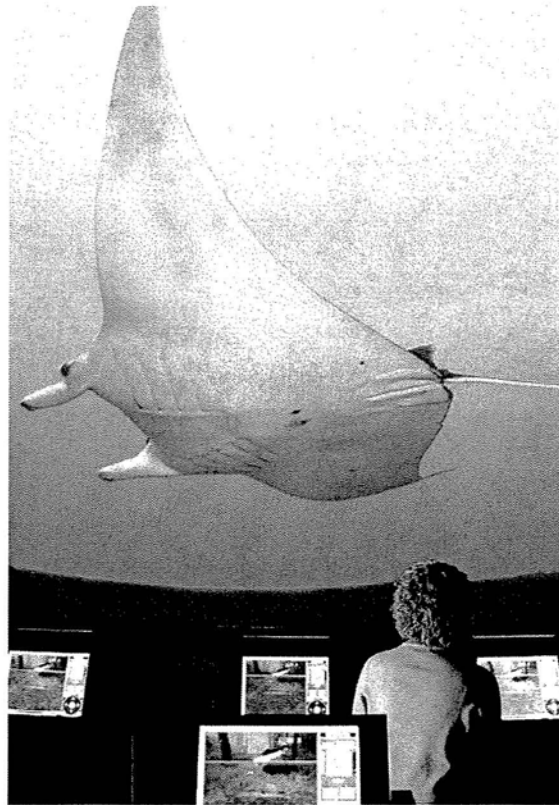
Preserving these video recordings and making them easily accessible for teaching and research is the aim of the Ethnomusicological Video for Instruction and Analysis (EVIA) Project. A joint effort of Indiana University and the University of Michigan, and supported in its initial phase by the Andrew T. Mellon Foundation, the EVIA project is coordinated by a team of experts in ethnomusicology, archiving, video, intellectual property, and digital technology. Ultimately, project plans include providing guidelines for future archives and establishing a functioning digital repository and delivery system for the current collection, which contains approximately 150 hours of digital video. Using the advanced network capabilities of Internet2, EVIA will provide high quality video streams to scholars for new research endeavors and to teachers for creating rich learning experiences.

INTERNET2®

Streaming high-quality digital video over advanced networks is essential to nearly all Internet2 applications, whether in the arts, sciences, or healthcare. Many initiatives in our member community are producing a new generation of digital video applications, advancing worldwide research and education.
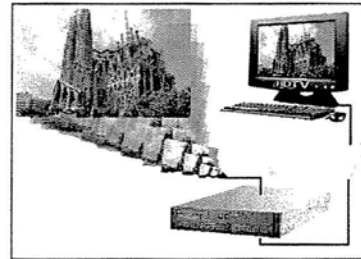
Streaming Video

Streaming Video

Interactive Video

Live Coast-to-Coast Undersea Video
University of California, Santa Cruz
University of Connecticut
VBrick Systems

http://mysticaquarium.org/newthings/articles/
immersion.asp

Visitors at Connecticut's Mystic Aquarium immerse themselves in an underwater world 3,000 miles away by remotely controlling underwater cameras in California. Using interactive consoles at the Mystic Aquarium's Immersion Institute, visitors control three video cameras on an underwater submersible in Monterey Bay, the largest U.S. marine sanctuary. The live video is encoded into DVD-quality MPEG-2 and sent at an average rate of 6 Megabits per second (Mbps) to the University of California, Santa Cruz, where it travels across Internet2 high-performance networks to the University of Connecticut and on to the Mystic Aquarium.

High Definition Video Array
ResearchChannel Consortium

http://researchchannel.org/inside/i2wg/projects.asp

ResearchChannel pushes the boundaries of High-Definition (HD) video over advanced networks with a variety of projects ranging from uncompressed, extreme-quality HD at 1.5 Gbps; to editable, studio-quality HD at 270 Mbps; to production-house-quality HD at 45 Mbps; to viewer-quality HD-to-the-desktop at 19.2 Mbps. Having successfully tested these prototypes, ResearchChannel will continue to develop projects involving networking configuration and hardware and software development. Areas of further work include uncompressed HD for interactive videoconferencing, decreasing the latency of 270 Mbps HD, and improving the desktop HD client.
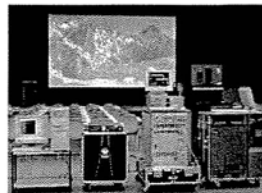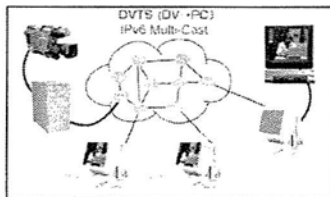
Super High Definition Video
Nippon Telegraph and Telephone Corporation
University of Illinois at Chicago
University of Southern California

http://www.onlab.ntt.co.jp/en/mn/

The successful transport of a Super High Definition (SHD) stream over advanced networks occurred at the Fall 2003 Internet2 Member Meeting, where an NTT system at the UIC Electronic Visualization Laboratory sent SHD to the Robert Zemeckis Center for Digital Arts at the USC School of Cinema-Television. SHD scientific visualizations and student films—four times the resolution of HDTV—were compressed to 200-400 Mbps streams using an experimental JPEG codec, stored, and sent to an NTT real-time decoder. NTT's prototype SHD frame buffer then fed an eight-megapixel projector for display.

Interactive Video

Digital Video Transport System
WIDE Project Japan

http://www.dvts.jp/en/
http://www.sfc.wide.ad.jp/DVTS/software/

Digital Video Transport System (DVTS) enables high-quality, real-time communication using free, downloadable software and off-the-shelf video and audio equipment. DVTS streams DV across advanced networks at 30 Mbps using Internet Protocol version 4 (IPv4) or 6 (IPv6). The DVTS client for Windows XP supports IPv6 unicast and multicast. PAL support has been included in the Mac OS X and Linux clients, and redundant audio transport capabilities have been added to improve audio performance in low packet-loss conditions. DVTS has been used to link instructors with students, and researchers with research laboratories around the globe.

The Access Grid 2.0
Argonne National Laboratory

http://www.accessgrid.org/

The Access Grid is a set of resources for multi-site, group-to-group collaborations over advanced networks, consisting of large-format video displays of participants, presentation sharing, and multimedia streaming. Access Grid version 2.0, released in May 2003, has been completely rebuilt using the Globus Toolkit for security and access to the Grid infrastructure. This allows developers to create advanced collaborative applications using the Access Grid Toolkit. The new Access Grid is capable of supporting a wider range of client platforms, including desktop computers, laptops, and traditional room-based nodes. The Access Grid project at Argonne National Laboratory is supported by the National Science Foundation, the U.S. Department of Energy, and Microsoft Research.

Virtual Rooms Videoconferencing System 3.0
California Institute of Technology

http://vrvs.org/

Virtual Rooms Videoconferencing System (VRVS) is a web-based system for interoperable videoconferencing and collaborating. VRVS supports multiple platforms—Windows, Mac, Linux, Unix—and diverse collaborative applications—Access Grid, H.323 videoconferencing, QuickTime, chat, desktop sharing, and, soon, Microsoft Messenger. Ninety-five percent of the code was re-written for the spring 2003 release of VRVS 3.0, which includes an advanced booking system, new virtual rooms for meeting spaces, a streamlined web-based user interface, firewall and NAT solutions, Access Grid tunneling, self-selection of video streams, user authentication, and synchronized time zones. No port reservations are required in order to initiate a videoconference—simply book a room in advance for any number of participants to join. Funding provided by the National Science Foundation and the U.S. Department of Energy.
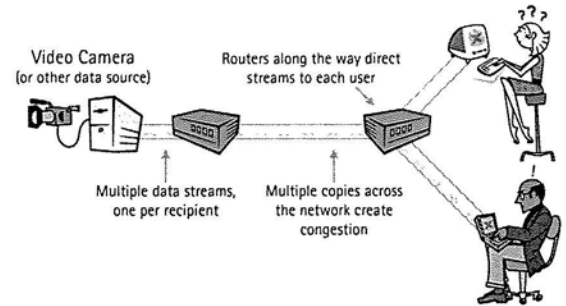
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www.internet2.edu

Internet2 members are developing and testing technologies that will give tomorrow's Internet the capabilities required by advanced network applications.

Internet2 Multicast

www.internet2.edu/multicast/

Multicast is a set of technologies that enables efficient delivery of data to many locations on a network. In today's Internet, the dominant model of communication is "unicast"—the data source must create a separate copy of the data for each recipient. When there are many recipients, and when large amounts of data (e.g. streaming video) are being sent, unicast becomes prohibitively wasteful of bandwidth. The key idea behind multicast (right) is to create each recipient's copy of each message at a point as close to that recipient as possible, thus minimizing the bandwidth consumed.

Unicast Streaming

Video Camera (or other data source)

Routers along the way direct streams to each user

Multiple data streams, one per recipient

Multiple copies across the network create congestion

Multicast Streaming

Video Camera (or other data source)

Routers along the way make copies for individual recipients *only as necessary*

Initially a single stream of data for all recipients

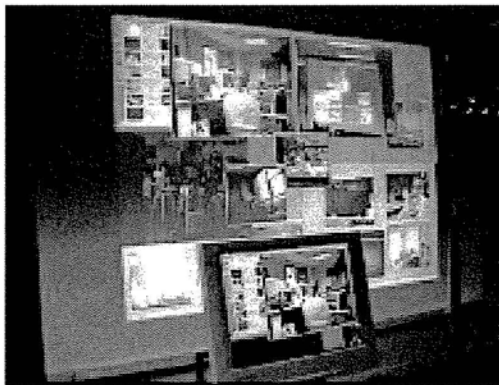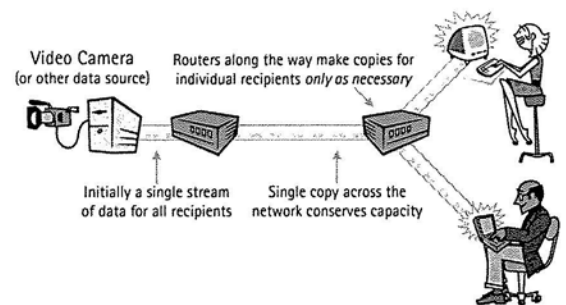Single copy across the network conserves capacity

Photo courtesy of Argonne National Laboratory, Mathematics and Computer Science Division

Network multicast capability is crucial for distance learning, digital video libraries, online collaboration tools, and other types of advanced applications important to research and education. For this reason, Internet2 members are at the forefront of multicast deployment. The Internet2 backbone networks vBNS and Abilene, as well as many Internet2 regional and campus networks, have fully deployed multicast. Multicast is routinely used to distribute better-than-TV-quality video to thousands of viewers at Internet2 universities. The Access Grid enables the creation of a potentially globe-spanning virtual conference hall (left).

Internet2's non-commercial research and education networks have made the speedy deployment of multicast possible. Through the work of Internet2's industry partners and of standards bodies such as the Internet Engineering Task Force, the technologies being tested in the Internet2 multicast effort are now making their way into the global Internet.

Tennessee State Education Network Connects to Internet2's Next-Generation Nationwide Network

Connection to Enable K20 Students Across the State to Participate in Leading-Edge Internet-Based Educational Opportunities

ANN ARBOR, Mich. - November 21, 2006 - Children across the state of Tennessee will soon have access to one of the fastest networks in the world. Internet2 today announced that Tennessee's statewide education network has become an Internet2 Sponsored Education Group Participant (SEGP) which will enable it to connect directly to Internet2's nationwide high performance network. Leveraging this connection, Tennessee will participate in the
Internet2 K20 Initiative which will provide its students access to cutting-edge, Internet-based educational opportunities not available today on the commercial Internet.

"Through this program, made possible through generous sponsorships by the University of Memphis and the University of Tennessee, teachers and students across Tennessee will be able to collaborate with their peers all over the world in virtual classrooms and laboratories that are revolutionizing the way young students learn - regardless of their physical location," said Dr.
Louis Fox, director, Internet2 K20 Initiative and vice provost, University of Washington. "Today, using Internet2 and other advanced technology, teachers aren't just telling students about oceanography or astronomy or chemistry - they are actually able to provide live multimedia experiences with high-definition images of the ocean floor or distant planets and stars or provide access to highly advanced equipment like remote electron microscopes, among many other resources."

The Tennessee SEGP, which will connect to Internet2's network through the University of Memphis, the University of Tennessee and Southern Crossroads (SoX), brings together Tennessee schools, libraries, community colleges, performing arts centers and museums. In particular, the network will be used promote inter-cultural exchanges through high quality video-conferencing with school districts in Korea, China and Russia. In addition, the connection has the potential to link The Tennessee School for the Deaf in Knoxville to other schools for the deaf in the region to experiment with high-quality/high-definition videoconferencing that enables them to better use sign language.

"The Tennessee SEGP program is truly a watershed opportunity for Tennessee," noted Dr. Doug Hurley, vice president for information technology and CIO at the University of Memphis. "SEGP 'flattens' the teaching and research landscape across Tennessee by enabling sharing and collaboration regardless of location or institutional type, in ways we have only dreamed of before."

The Tennessee K20 community will also be able to tap into already established programs under the Internet2 K20 initiative like master music classes taught by world-renowned musicians at the New World Symphony or the Manhattan School of Music using DVD-quality videoconferencing or events like Mega-conference Jr., an annual project that uses videoconferencing technology to bring together thousands of students in elementary and secondary schools from around the world for an all-day learning conference. Tennessee students can also to take part in famed oceanographer Bob Ballard's immersion project to receive live interactive undersea exploration demonstrations from divers in remote locations around the world.

Brice Bible, University of Tennessee CIO said "Internet2 represents one of the most advanced networks in the world. The Tennessee SEGP program allows all Tennessee students and faculty to collaborate and participate in innovative learning experiences wherever they may be."

For more information, visit: http://k20.internet2.edu

About Internet2
Internet2 is the foremost U.S. advanced networking consortium. Led by the research and education community since 1996, Internet2 promotes the missions of its members by providing both leading-edge network capabilities and unique partnership opportunities that together facilitate the development, deployment and use of revolutionary Internet technologies. Internet2 brings the U.S. research and academic community together with technology leaders from industry, government and the international community to undertake collaborative efforts that have a fundamental impact on tomorrow's Internet. For more information: http://www.internet2.edu/

About the Internet2 Sponsored Educational Group Participant (SEGP) Program
The SEGP program is intended to allow expanded access to the Internet2 Abilene network for state and regional education networks, through sponsorship by Internet2 university members. State and regional networks may include nonprofit and for-profit K20 educational institutions, museums, libraries, art galleries, or hospitals that require routine collaboration on instructional, clinical and/or research projects, services and content with Internet2 members or with other sponsored participants. The program began in early 2001 and has since connected 35 state K-12/K-20 networks.

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www.internet2.edu

Internet2 advanced applications are helping instructors develop new teaching techniques, enhancing the learning experience for students, and extending universities beyond their geographical boundaries. By bringing together learning communities and removing barriers to information retrieval and learning resources—Internet2 applications are changing the way we learn and teach.

Undergraduate Education

Distance Learning

Collaboration Tools

Remote Instrumentation
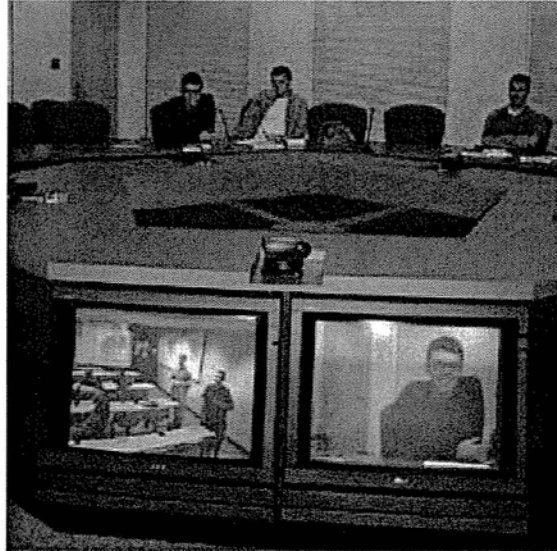
Undergraduate Education

Screenwriting Course
Bradley University

http://gcc.bradley.edu/slane/

In order to be competitive in the entertainment industry job market, university graduates need to know how the industry works from top to bottom. But, how do you expose students to agents, writers, directors, and producers? And, how do you do it from Peoria, Illinois? Jeffrey Huberman, Dean of the Slane College of Communications and Fine Arts at Bradley University, explains, "We provide students with an excellent education in many aspects of the entertainment industry, but we didn't offer a course in screenwriting. We thought Internet2 advanced network technology could provide a solution." Huberman collaborated with California State University, Los Angeles (CSLA) to create a screenwriting course, which enrolled students at both Bradley and CSLA. The course included guest lectures by agents, screenwriters, and production executives—brought live to the classroom via interactive videoconferencing. Through the use of advanced networking technology, students learned all the steps involved in bringing a project to production from professionals who are successfully managing careers in Hollywood.

Distance Learning

Singapore-MIT Alliance
Massachusetts Institute of Technology
National University of Singapore
Nanyang Technological University

http://web.mit.edu/sma/

The Singapore-MIT Alliance (SMA) is an advanced engineering degree program that combines an innovative distance-learning component with traditional on-campus learning. SMA is a highly-collaborative effort that provides thousands of students with courses using the most technologically-advanced distance learning facilities available. SMA course offerings use a live lecture format delivered via videoconferencing with supplemental data content provided over an application sharing link. Vijay Kumar, Assistant Provost & Director of Academic Computing at MIT, comments, "Our goal is to improve the educational experience and meet the lifelong learning needs of our students while simultaneously expanding MIT's reach and influence by providing educational offerings to a global audience."

Integrated Seminar in Nursing Informatics
Committee on Institutional Cooperation

http://www.cic.uiuc.edu/programs/CICCourseShare/

The Committee on Institutional Cooperation (CIC), a consortium of 12 research universities, piloted a course in nursing informatics for four participating institutions: University of Iowa, University of Wisconsin-Madison, Indiana University, and University of Michigan. This innovative course used the Internet2 Commons H.323 Videoconferencing Service to deliver live, interactive lectures to students. The course was supplemented by an on-demand video archive and web-based conferencing and course management. The four participating universities used CIC's CourseShare administrative system, which allows students to register and pay tuition, receive grades and credit for specialized inter-institutional courses all at their home campuses. Connie Delaney, professor at the College of Nursing at the University of Iowa, stresses, "This collaboration provides creative strategies that leverage the scarcity of nursing informatics faculty and at the same time offers students participation in a wealth of research projects and innovations across multiple institutions."
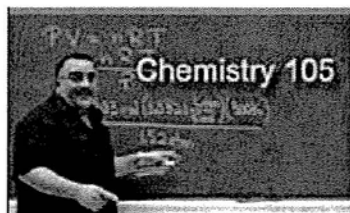
Collaboration Tools

MediaVision and Chemistry 105
Case Western Reserve University

http://www.cwru.edu/its/itac/mediavision/

MediaVision Courseware is an advanced instructional technology project that enhances existing teaching methods with new multimedia learning content. For Chemistry 105—a large, lecture-style undergrad chemistry course—MediaVision provides students with video recordings of lectures, review sessions, and homework assistance; MP3 audio recordings; and an on-line textbook. Lectures and review sessions are recorded; encoded for network distribution; indexed and "published" to the web where they can be keyword searched by students. Network-based delivery extends access to the multimedia materials both on and off campus, which is especially critical to commuting students. MediaVision Courseware illustrates how technology can improve the educational outcome as well. During the first semester of Chemistry 105 using the MediaVision Courseware, scores for the first two tests rose to an 81 average, from a previous average of 72.

Digital Anatomy
Stanford University
University of Wisconsin — La Crosse

http://havnet.stanford.edu/

When Stanford University medical students "dissect" an anatomical specimen, they zoom in, rotate it, dissect it, and even put it back together again. Remote Stereo Viewer (RSV) is an educational tool that allows medical educators and students to view 3D stereo anatomical interactive photographs on a workstation. Since an anatomical specimen can be viewed in various stages of dissection, the student can go back and forth between layers to better understand the complexity of the structure. The high-resolution 3D stereo images are stored on a server and then individually downloaded to a workstation on demand, requiring high-bandwidth transport at a minimum of 35 Mbps. RSV is used in a "virtual classroom" style setting that allows multiple, remote users to access digital anatomy datasets and collaboratively view and discuss a virtual dissection in real-time. Dr. Sakti Srivastava has been using this tool for over three years in the gross anatomy class at Stanford and comments, "When we conducted field trials to evaluate the usability and learning efficacy of the applications, we discovered that its simple, user-friendly interface and high quality images made it an attractive option for students. When RSV was used both as an introduction to a real dissection and as a refresher after the dissection had been completed, students self-rated themselves as having better learnt the concepts and details."

Remote Instrumentation

Remote Microscopy Course
University of Michigan
Lehigh University

http://emalwww.engin.umich.edu/
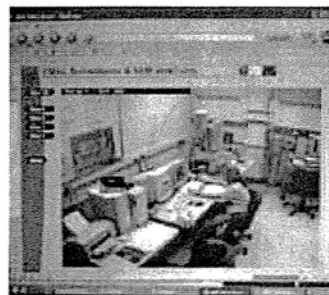
A Scanning Electron Microscope (SEM) at the University of Michigan (UM) plays a key role in courses taught at Lehigh University. Each year, the Lehigh Microscopy School attracts over 100 engineers and scientists who receive instruction in a wide variety of microscope techniques using SEMs and other state-of-the-art instruments. One of these instruments is the Philips XL30FEG SEM located in the Electron Microbeam Analysis Laboratory (EMAL) at UM. The Philips line of SEMs was one of the first to be completely computer-controlled, as opposed to the knob and switch "interfaces" on older instruments. Extending its usability via remote-control to an Internet-wide audience resulted from the work of Dr. John Mansfield and collaborators. Mansfield, Manager of EMAL, explains, "Advanced networks provide the bandwidth and performance required to control the SEM in real-time from anywhere in the world. Remote access extends the use of this extremely costly resource for instructional and collaborative research purposes."

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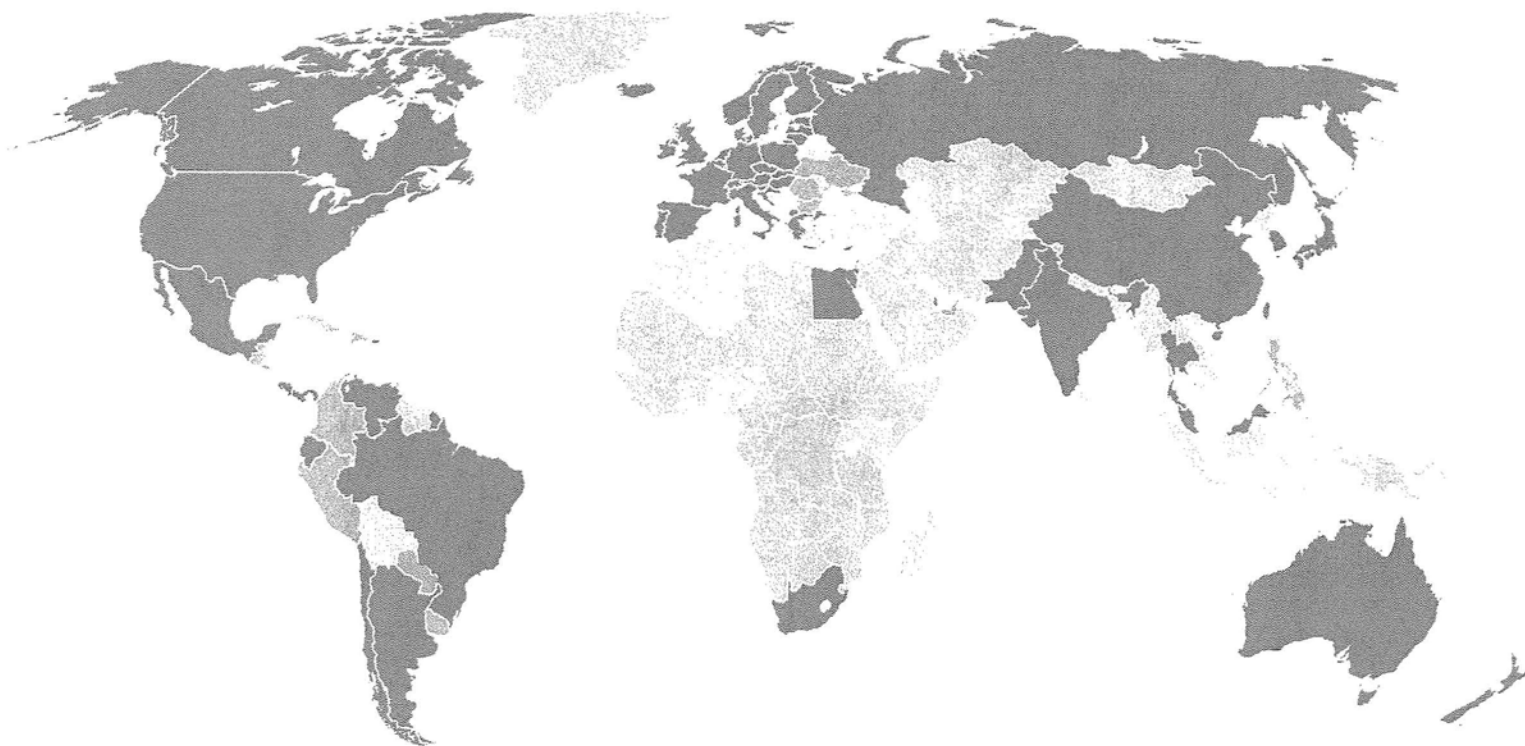
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Developing Partnerships

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Colombia
Dominican Republic
El Salvador
Guatemala

Paraguay
Pakistan
Palestinian Authority
Peru
United Arab Emirates
Uruguay

Albania
Algeria
Bolivia
Bosnia / Herzegovina
Cuba
Cyprus
Ghana
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Jamaica
Jordan
Kenya
Lebanon
Macedonia
Madagascar

Malta
Montenegro
Morocco
Nicaragua
Nigeria
Philippines
Romania
Senegal
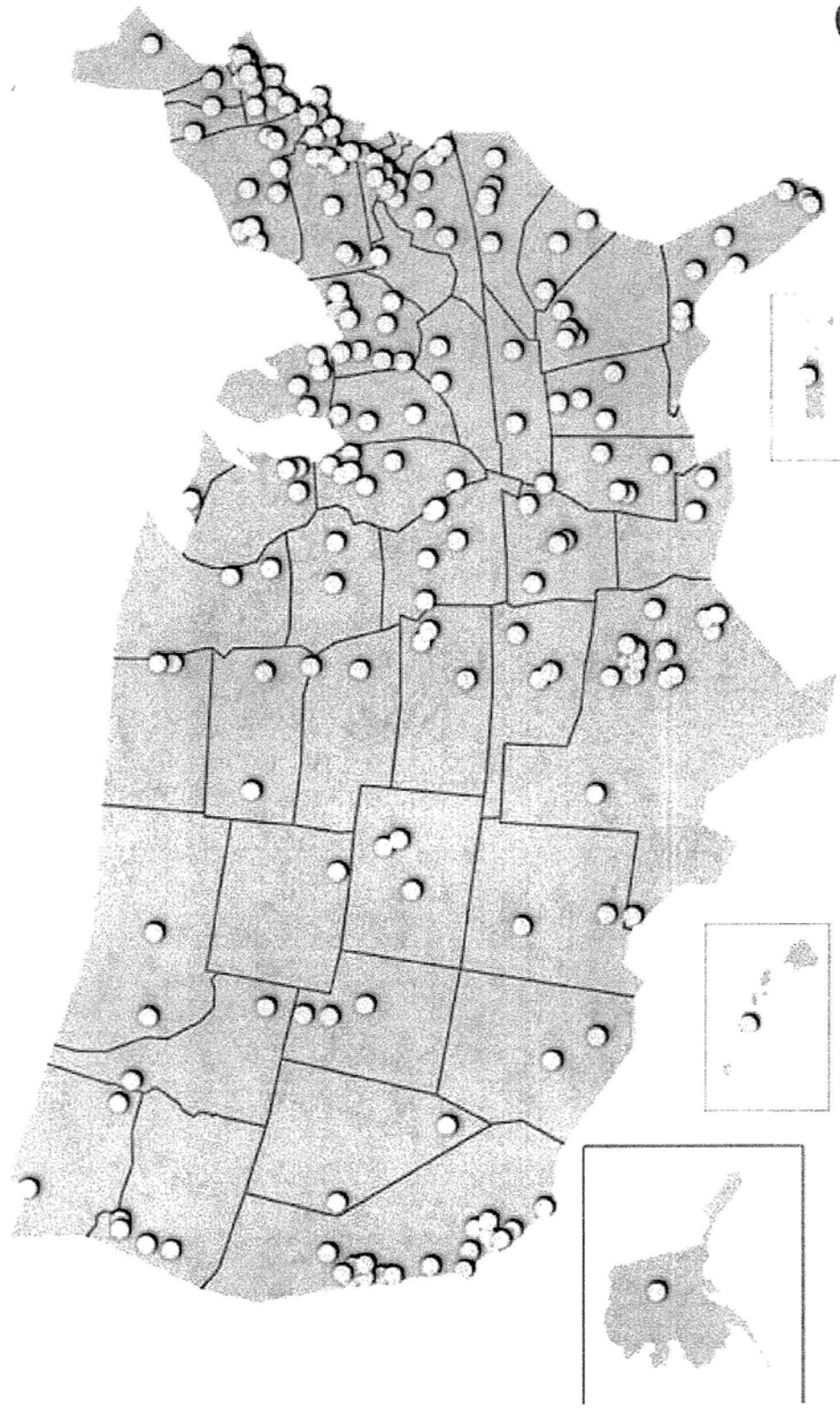Serbia
Sri Lanka
Syria
Tunisia
Turkey
Uganda
Vietnam

Related Partnerships

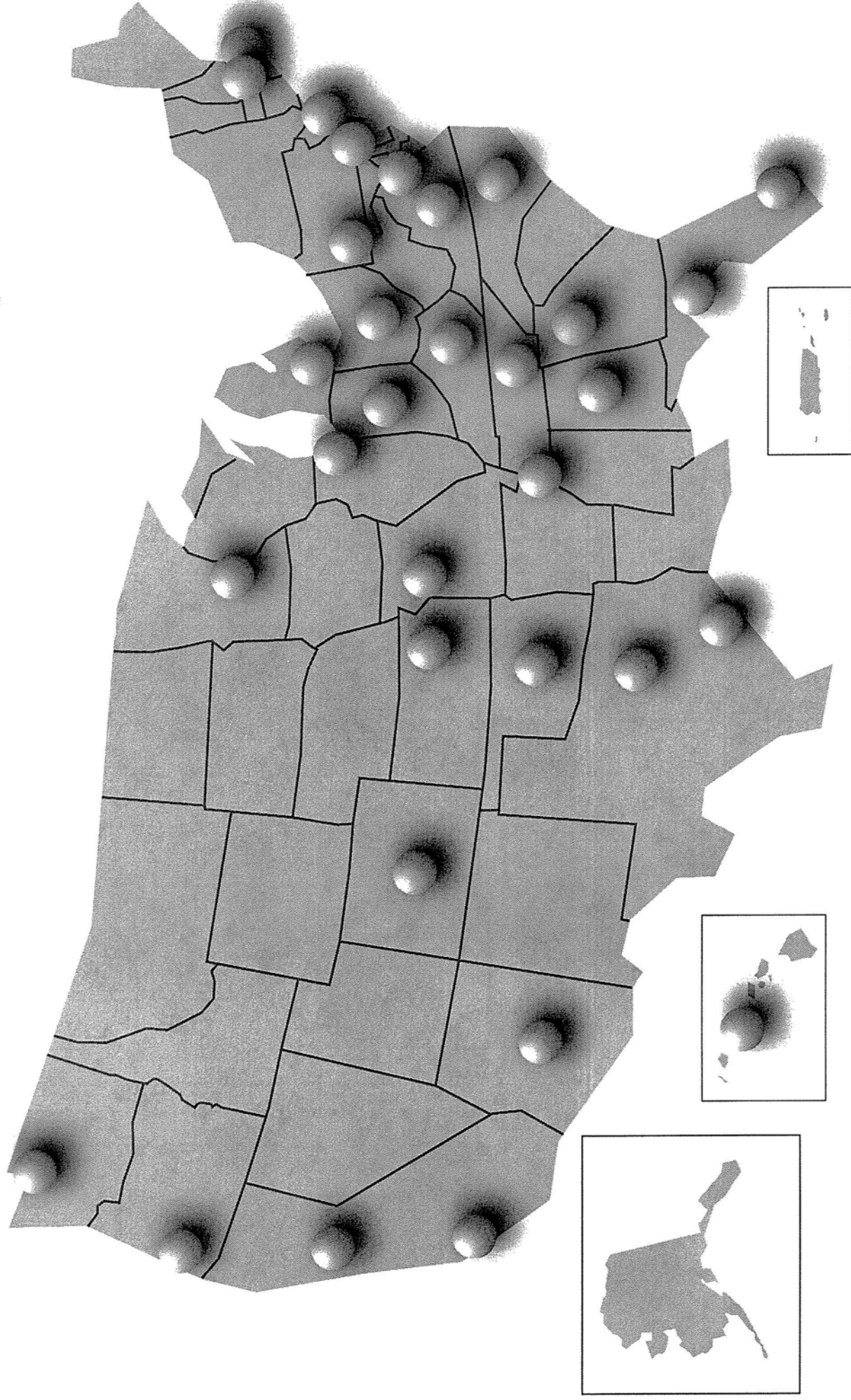APRU (Asia Pacific)
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The World Bank

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